



BASIC RESEARCH ARTICLE



Recall bias secondary to major trauma: results from a prospective study of the Beirut Port Blast

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ABSTRACT

Background: Traumatic events are often perceived as unforgettable, yet scientific evidence highlights the complexity of memory recall in the aftermath of traumatic experiences. While some studies observed amplification of traumatic memory, others reveal rapid forgetfulness and falsification of details.

Objective: The primary objective of this study is to investigate how initial memories of the Beirut Port Blast in 2020 fluctuate over time. Going beyond full-threshold self-reported post-traumatic stress disorder (PTSD) and self-reported acute stress disorder (ASD), the research aims to explore subthreshold self-reported PTSD and individual self-reported ASD symptoms as potential predictors of recall bias among healthcare workers.

Method: This study draws on data from four waves of the ongoing B.L.A.S.T. (Beirut Longitudinal Assessment Study of Trauma) study which spans so far over a period of two years.

Results: Being a clinical professional and having higher self-reported ASD symptoms in wave 1, specifically intrusion symptoms, were associated with recall diminishment. Higher self-reported PTSD, subthreshold self-reported PTSD diagnoses (six plus or majority) and higher anxiety scores were significantly associated with exaggeration of recall.

Conclusion: The study underscores the importance of assessing a broad range of symptoms, beyond conventional diagnoses, to gain a comprehensive understanding of how traumatic memories are recalled and potentially altered over time.

Sesgo de recuerdo secundario a un trauma mayor: resultados de un estudio prospectivo sobre la Explosión del Puerto de Beirut

Antecedentes: Los eventos traumáticos suelen percibirse como inolvidables, sin embargo, la evidencia científica destaca la complejidad del recuerdo en el contexto de experiencias traumáticas. Mientras algunos estudios han observado una amplificación de la memoria traumática, otros revelan un rápido olvido y la falsificación de detalles.

Objetivo: El objetivo principal de este estudio es investigar cómo fluctúan con el tiempo los recuerdos iniciales de la explosión del puerto de Beirut ocurrida en 2020. Más allá de los diagnósticos autoinformados y con umbral completo de trastorno de estrés postraumático (TEPT) y trastorno de estrés agudo (TEA), la investigación busca explorar diagnósticos subumbrales de TEPT autoinformado y síntomas individuales de TEA autoinformado como posibles predictores de sesgo de recuerdo entre trabajadores de la salud.

Método: Este estudio se basa en datos de cuatro mediciones del estudio en curso B.L.A.S.T. (Estudio de Evaluación Longitudinal del Trauma en Beirut), que hasta la fecha se ha extendido durante un período de dos años.

Resultados: Ser profesional clínico y presentar mayores síntomas de TEA autoinformados en la primera medición, especialmente síntomas de intrusión se asociaron con una disminución del recuerdo. Por otro lado, un mayor nivel de TEPT autoinformado, diagnósticos subumbrales de TEPT (seis o más síntomas, o la mayoría de ellos), y puntuaciones más altas de ansiedad se asociaron significativamente con la exageración del recuerdo.

Conclusión: El estudio subraya la importancia de evaluar una amplia gama de síntomas, más allá de los diagnósticos convencionales, para comprender de manera integral cómo se recuerdan y potencialmente se alteran las memorias traumáticas con el paso del tiempo.

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HIGHLIGHTS

- Clinical professionals exhibited lower trauma recollection than non-clinical professionals.
- Self-reported acute intrusive symptoms were linked to diminished trauma recall over time.
- We discovered that more severe self-reported PTSD, including subthreshold self-reported PTSD (which assess spectrum of symptoms), was linked to exaggerated memories of the trauma.

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1. Introduction

Although traumatic events are often considered unforgettable, evidence shows that memory recall of such events is inconsistent. In fact, some studies suggest that non-traumatic events are often recalled more consistently than traumatic ones (Strange & Takarangi, 2012). This inconsistency, known as *traumatic recall bias*, refers to the tendency to recall traumatic events inaccurately, either by amplifying or diminishing the perceived severity of the trauma, whether it is natural or man-made.

1.1. Amplification of traumatic memories

Many studies have documented the amplification of traumatic memories. Roemer et al. in a longitudinal study of 460 veterans from the Somalian peacekeeping mission, found that as posttraumatic symptoms increased, so did reports of the stressor frequency, such as being fired at, seeing Somalis dying, and going on dangerous duties (Roemer et al., 1998). Similarly, Giosan et al., who studied 2641 World Trade Center restoration workers, found that the perceived severity of the traumatic events (life threat, seeing human remains, etc.) increased over time, especially among those with severe post-traumatic stress disorder (PTSD), as assessed one year post attacks (Giosan et al., 2009). Southwick et al. further demonstrated that changes in responses regarding traumatic exposure (from no to yes) between one month and two years after combat were significantly positively correlated with PTSD severity using the Mississippi Scale for Combat-Related PTSD (Southwick et al., 1997). The authors suggested several reasons for this change. First, initially denied, repressed, or suppressed memories at 1 month became conscious at two years. Second, exposure to media and various narrations from other traumatised individuals may have led the subjects to exaggerate their memories. Third, memories, flashbacks, and nightmares could have led individuals to involuntarily re-experience symptoms, and hence, gradually help with the recall of traumatic memories. Fourth, individuals who are overwhelmed by their increasing symptoms might have unconsciously exaggerated their memories to rationalise their emerging psychopathology.

1.2. Diminishment of traumatic memories

While amplification is common, there is also evidence of diminished trauma recall. For instance, Hirst et al. after the 9/11 2001 World Trade Center attacks in the USA, followed up on a convenient sample who reported rapid forgetfulness and falsification of details of the memories collected 1-year later, with a persistence of this forgetfulness for 10 years (Hirst et al., 2009). Similarly, two years after the Gulf War, 46% of

veterans no longer reported traumatic events they had previously acknowledged one month post-war (Southwick et al., 1997). This reduction of trauma recollection is thought to be due to memory suppression to avoid conscious recollection, media influence (media's minimisation of the trauma), or initial overestimation of the traumatic experience. Additionally, as PTSD symptoms decrease, individuals may reconstruct their experiences as less severe, in line with their improved mental state. Vietnam veterans, for example, reported significantly less combat exposure in 1998 when they no longer met the criteria for PTSD diagnosis compared to their initial reports 14 years earlier in 1984 when they had active PTSD diagnosis (Koenen et al., 2007). Other studies have highlighted that an individual's initial response to trauma plays a key role in diminished recall. Restoration workers from the 9/11 attack who exhibited PTSD numbing and avoidance reported endorsements of traumatic experiences in follow ups (Giosan et al., 2009).

Positive life events prior to the traumatic event can also reduce recall. Adults who reported such events before the 1998 Chicago school shooting experienced less sensory and emotional distress (Schwarz et al., 1993), potentially contributing to a minimised perception of the trauma and more confidence in handling trauma related stress. Lastly, Harvey et al. found that Acute Stress Disorder (ASD) impairs trauma memory retrieval (Harvey et al., 1998), with more severe acute stress response associated with worse recall of both positive and trauma-related information (Moulds & Bryant, 2005).

Building on existing literature, which has primarily examined veterans, restoration workers, and the general population, our current study will focus on healthcare workers. While there is no prior research specifically addressing recall bias among healthcare workers, we hypothesise that similar patterns observed in other frontline workers may be applicable. Specifically, we anticipate that healthcare workers may diminish their recollection of traumatic events as a coping mechanism to protect their professional identity (Dutheil et al., 2019). Healthcare workers are consistently under pressure to maintain emotional resilience and composure in high-stress environments, where they routinely deliver difficult news and are frequently exposed to illness, suffering, and death (Olfson et al., 2023). Additionally, the stigma surrounding trauma in healthcare professions may discourage workers from fully acknowledging or recalling traumatic experiences, as they may fear that doing so could undermine their perceived competence and professionalism.

This study aims to explore how initial memories of the Beirut Port Blast – one of the most powerful non-nuclear explosions ever recorded – fluctuate over time among healthcare workers as well as assess the associations with these fluctuations. While previous research

has investigated the association of recall bias with PTSD and ASD, this study will extend its scope to include subthreshold self-reported PTSD. It is noteworthy that sub-threshold symptoms often carry clinical significance, necessitating intervention, and are amenable to treatment due to showcasing levels of distress, impairment, suicidality, and comorbidity that is not captured in the full-threshold provisional diagnosis of PTSD (Cukor et al., 2010; Favaro et al., 2006; Gellis et al., 2010; Jakupcak et al., 2007). In order to accomplish this objective, the data utilised in this article stems from four phases of our ongoing B.L.A.S.T. study (Beirut Longitudinal Assessment Study of Trauma) following the Beirut Blast.

2. Methods

2.1. Participants & procedure

The data sets were collected in a cohort research project following the Beirut Port Blast. Participants included health workers at Saint George Hospital University Medical Center (SGHUMC) which is one of the most extensively damaged healthcare centres (Fleifel & Abi Farraj, 2022). Participants in this study belonged to all departments including clinical staff, administrative staff, as well as supportive staff (e.g. food services, environmental services). In Lebanon, the minimum legal working age is 18, thus all participants in this study aged 18 or older.

Recruiting from all different departments at SGHUMC resulted in a sample with variability in the distribution of risk/protective factors related to our study. We conducted four waves of our longitudinal study: 9–15 days, 21–27 days, 6–7 months, and 2–2.5 years post blast. Immediately post blast (9–15 days), data for wave 1 was collected after the hospital administration urged all its workers who got in direct or indirect contact with a stranger during the blast to undergo Polymerase Chain Reaction (PCR) testing because of the prevailing COVID-19 pandemic. The data collection for wave 1 took place face to face using self-filled questionnaire in private in the PCR screening area. Due to the urgency of the situation, and the chaos post blast accompanied with a wide destruction of the hospital's offices and floors, we collected data on 570 participants, but we couldn't estimate the response rate for wave 1. Waves 2, 3, and 4 at 21–27 days, 6–7 months, and 2–2.5 years involved gathering data through an online-based platform. This process included sending out the links through mass emails from MailChimp, along with reminders via SMS and WhatsApp, as well as personalised letters containing QR codes. The list of total workers at SGHUMC was obtained from the hospital's human resources. In our study, the total number of participants in waves 2, 3 and 4 were 733, 808 and 540

corresponding to response rates of 38.0%, 41.8%, and 40.5% respectively. Due to the design of our study, which utilised an open cohort approach, participants could join at various waves. Each wave focused on tracking subjects across all four phases while simultaneously working to expand our sample size and recruit additional participants in every wave.

This study was approved by the Institutional Review Board (IRB) committee of the SGHUMC Faculty of Medicine, University of Balamand, Lebanon, which is registered with the US Office of Human Research Protections (OHRP) in the Department of Health and Human Services.

2.2. Instruments and measures by waves

2.2.1. Beirut Port blast exposure inventory

The Beirut Port Blast Exposure Inventory inquired about nine specific types of exposure to the Beirut Port Blast: (1) location at the time of the explosion; (2) personal physical injuries; (3) problems in receiving any needed medical attention (if physically injured); (4) mild injuries to a loved one; (5) severe injuries to a loved one; (6) death of a loved person; (7) damage to the place of residence; (8) participating in rescue efforts at or outside the hospital; and (9) seeing any mutilated or dead bodies. The nine exposures assessed were studied in two different ways: specific exposures (0 = No, 1 = Yes) and a weighted exposure score. To generate the weighted exposure score, a panel of 20 experts from our centre (clinicians, statisticians, public health experts) were asked to give a weight to each event ranging from 0 to 100. The final weight attributed to each exposure was the median of all reported weights for this event by the panel. The final weighing score was the cumulative score of all the events experienced and the weights attributed to them. Further details can be found elsewhere (Karam et al., 2022).

2.2.2. Acute stress disorder measure

We assessed the ASD using a self-report measurement which is the most established measurement of ASD: The Acute Stress Disorder Scale (ASDS). It has good psychometric characteristics when validated against the golden standard Acute Stress Disorder Interview (ASDI) for Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) with a sensitivity of .95, specificity of .83, positive predictive value (PPV) of .80, and a negative predictive value (NPV) of .96 (Bryant et al., 2000). The ASDS consists of 21 items, 19 of which ask about symptoms of acute stress following a trauma. Each of these 19 items is coded on a 5-point scale (1 = not at all, 5 = very much) and the summation of scores provides a total severity score. Participants were also asked if they experienced fear during the blast and the extent to which any symptoms caused them distress/dysfunction mainly related

to the interference of the symptoms with their occupational or personal functioning (Bryant et al., 2000). The original English ASDS scale was translated to Arabic, by our team; although it was not standardised in the Arabic Language, yet it showed an excellent internal consistency of 0.94. To derive a probable DSM-5 definition of ASD, the 14 relevant symptoms were used to derive a probable ASD diagnosis by endorsing at least 9 symptoms (Bryant et al., 2000), so a participant scoring 9 or above out of 14 is considered positive for probable DSM-5 ASD. Further information on the ASD symptoms which include intrusion, negative mood, dissociation, avoidance and arousal can be found in the supplementary material.

2.2.3. Posttraumatic stress disorder

The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5) is a well-established 20-item self-report measure that assesses the 20 DSM-5 symptoms of PTSD. Each symptom rating was between 0–4 corresponding to: ‘Not at all,’ ‘A little bit,’ ‘Moderately,’ ‘Quite a bit,’ and ‘Extremely.’ For the full-threshold DSM-5 provisional diagnosis of PTSD, the symptom was considered endorsed if the participants reported experiencing the symptom moderately or more. The DSM-5 diagnostic rule required at least: 1 B item (questions 1–5), 1 C item (questions 6–7), 2 D items (questions 8–14), 2 E items (questions 15–20). The PCL-5 had an excellent internal consistency in this sample (0.92). While a substantial proportion of adults encounter traumatic events over their lifetimes, only a minority fulfil the criteria of full-threshold PTSD, yet, a significant number manifest PTSD symptoms that fall within the sub-threshold PTSD classification (Breslau et al., 2004; Stein et al., 1997; Weiss et al., 1992).

For our study, we used two definitions for the sub-threshold DSM-5 PTSD (McLaughlin et al., 2015), the ‘six plus’ definition: Having at least six symptoms of PTSD, but not meeting full criteria due to failure to meet criterion specifiers and the ‘majority’ definition: meeting full threshold for 3 criteria of the four criteria B–E. As for the self-reported PTSD score, a total symptom severity score (range –0–80) was obtained by summing the scores for each of the 20 items.

2.2.4. Depressive symptoms

The Patient Health Questionnaire-9 (PHQ-9) is a 9-item self-administered version of the depression module of the Primary Care Evaluation of Mental Disorders (PRIME-MD), which is based on the DSM-IV criteria for major depression (Kroenke et al., 2001). Referring back to the past two weeks, participants answered if they had experienced symptoms that tend to be associated with depression. The possible answers and respective scores were: ‘not at all’ (0), ‘less than 1 week’ (1), ‘1 week or more’ (2), and ‘almost every day’ (3). The total PHQ-9 score was obtained by adding all the items

together with a range from 0–27 with higher scores suggesting evidence of depression. The internal consistency of the PHQ-9 in this sample was good (0.89).

2.2.5. Anxiety symptoms

The Generalised Anxiety Disorder scale (GAD-7) is a concise and effective tool for evaluating generalised anxiety disorder (GAD) (Spitzer et al., 2006). This self-report questionnaire consisted of 7 questions, designed to assess the severity of GAD symptoms in individuals over the past two weeks using a 4-point scale (from 0 to 3). The total score ranged from 0–21 with higher scores indicating higher levels of anxiety. The internal consistency of the GAD-7 in this sample was good (0.87).

Wave 1 and wave 2 questionnaire included in addition to sociodemographic questions (age, gender, and profession), the Beirut Port Exposure Inventory (Karam et al., 2022), and the self-reported ASDS (since both took place in less than a month after the blast) (Bryant et al., 2000). Wave 3 was carried out in collaboration with the Health Care Workers (HEROES) international effort to evaluate the multiple aspects of COVID-19 exposure among healthcare workers, across 26 countries (Mascayano et al., 2022). In Lebanon and in addition to the COVID-19 exposure, we focused on the individual and collective extent of the economic meltdown as well as the long-term impact of the Beirut Port Blast which continued in to a wave 4 as an exclusive effort by the Lebanon team. Wave 3 (the HEROES initiative) questionnaire included the Beirut Port Exposure Inventory in addition to a broad range of questions among them PCL-5 and the PHQ-9 screener for depression. Similar to wave 3, wave 4 questionnaire included the Beirut Port Exposure Inventory, PCL-5 and PHQ-9, and the GAD-7 screener for anxiety.

In the current paper, the blast exposure of the first two waves of the survey were considered as baseline (B) (Blast exposure reported within 1-month post blast); the data including recollection of trauma collected in the third wave (6–7 months post blast) were considered follow-up 1 (F1) and those collected in wave 4 (2 years post trauma) were considered follow-up 2 (F2). To clarify, all participants in wave 1 were asked to complete the entire questionnaire, including sociodemographic questions (age, gender, and profession), the Beirut Port Exposure Inventory, and the self-reported ASDS. In wave 2, participants who had already responded in wave 1 were not asked to complete the sociodemographic nor the Beirut Port Exposure Inventory again, but only the self-reported ASDS. As both waves 1 and 2 were conducted less than one-month post-blast, the data from waves 1 and 2 were merged together in terms of the Blast exposure data and treated as baseline. Henceforth, the detailed breakdown of the participants included in the analysis of this paper and whom we had data

on longitudinally as we were able to follow them up across waves were as follows:

- Total Number of participants followed from baseline (B) to follow-up 1 (F1, 4–7 months post blast) is 426, pertaining to waves 1, 2, and 3.
- Total Number of participants followed from baseline (B) to follow-up 2 (F2, 2–2.5 years post blast) is 264, pertaining to waves 1, 2, and 4.

2.3. Statistical analysis

Recall Bias: To index recall bias, we calculated differences between endorsement of items on the Beirut Port Blast Exposure Inventory. Specifically, we computed different frequency distributions to describe the amount of change in the sample: (a) no at baseline and no at follow-up; (b) yes at baseline and yes at follow-up; (c) no-to-yes shifts; (d) yes-to-no shifts; (e) total number of changes of either type. We also generated a crude count of the number of changes across items for each study participant. All the descriptive details can be found in the supplementary material (Supplementary Tables 1, 2 & 3).

For the outcome in this study, we created a subtraction variable between the weighted score of exposure at different waves (baseline minus follow-up 1/ baseline minus follow-up 2) to reflect recall bias for each participant:

- Those who scored negative on the subtraction are recoded and considered people with exaggeration on the exposure over time.
- Those who scored positive are recoded and considered people with diminishment on the exposure over time.
- Those who scored zero had no change in their response over time.

Associations: Potential associations with exaggeration and diminishment compared to no change in exposure response from baseline to follow-up 1 and from baseline to follow-up 2 were investigated using multinomial logistic regressions. The sociodemographic factors (age, gender, profession) and mental health disorders (self-reported ASD diagnosis, self-reported ASD severity, self-reported full-threshold PTSD, self-reported PTSD Severity, self-reported PTSD subthreshold, Anxiety and Depression) were included separately. We generated odds ratios (ORs) and *p*-values with 95% confidence intervals (CIs). A *p*-value < .05 is considered statistically significant.

3. Results

3.1. Descriptive

Tables 1 and 2 show the description of the full sample at different waves. Tables 3 and 4 (first column)

Table 1. Description of study participants at baseline (Waves 1 and 2).

	Baseline (within 1 month)	
	Wave 1 (9–15 days)	Wave 2 (21–27 days)
<i>N</i> (Response Rate)	570 (NA)	730 (38%)
Age (Mean ± SD)	34.05 ± 11.14	34.66 ± 11.31
Gender <i>N</i> (%)		
Males	197 (34.62%)	249 (34.06%)
Females	372 (65.38%)	482 (65.94%)
Profession <i>N</i> (%)		
Non-Clinical	139 (26.23%)	232 (32.58%)
Clinical	391 (73.77%)	480 (67.42%)
ASD Diagnosis <i>N</i> (%)		
No ASD	320 (61.66%)	504 (70.00%)
ASD	199 (38.34%)	216 (30.00%)
ASD Severity (Mean ± SD)	48.76 ± 16.65	43.78 ± 16.13

present the characteristics of the subsample analysed from baseline to follow-up 1 and from baseline to follow-up 2, respectively.

3.2. Participants followed up from baseline to Follow-up 1 (Table 3)

As previously mentioned, we followed up 426 participants from baseline to follow-up 1. Of these 426, 356 participants had complete data on sociodemographic factors, the exposure inventory and the mental health disorders (see Table 3 for descriptive statistics). The remaining 70 participants had missing information, which led to their exclusion.

In terms of recall bias, of the total participants included in the analysis (*N* = 356), 82 participants (23.03%) did not change their response while 154 (43.26%) reported diminishment and 120 (33.71%) reported exaggeration of exposure.

3.2.1. Associations with exaggeration

As shown in Table 3, higher self-reported PTSD scores were significantly associated with exaggeration of trauma exposure (OR = 1.02, *p*-value = .041, 95%CI

Table 2. Description of study participants at Follow-ups 1 and 2 (Waves 3 and 4).

	Follow-up1 (6–7 months)	Follow-up2 (Around 2 years)
	Wave 3	Wave 4
<i>N</i> (Response Rate)	808 (41.8%)	540 (40.5%)
Age (Mean ± SD)	36.90 ± 12.36	41.02 ± 13.39
Gender <i>N</i> (%)		
Males	236 (29.28%)	151 (28.6%)
Females	570 (70.72%)	377 (71.30%)
Profession <i>N</i> (%)		
Non-Clinical	200 (24.94%)	144 (26.67%)
Clinical	602 (75.06%)	396 (73.33%)
Self-reported PTSD <i>N</i> (%)		
No self-reported PTSD	587 (72.65%)	479 (88.70%)
Self-reported PTSD	221 (27.35%)	61 (11.30%)
Self-reported PTSD Severity (Mean ± SD)	23.75 ± 15.78	18.62 ± 13.60
Self-reported PTSD Six Plus <i>N</i> (%)		
No self-reported PTSD	360 (48.06%)	278 (57.44%)
Self-reported PTSD	389 (51.94%)	206 (42.56%)
Self-reported PTSD Majority <i>N</i> (%)		
No self-reported PTSD	387 (51.67%)	348 (71.60%)
Self-reported PTSD	362 (48.33%)	138 (28.40%)
Depression (Mean ± SD)	5.42 ± 5.32	5.19 ± 4.2
Anxiety (Mean ± SD)	–	5.31 ± 4.7

Table 3. Multinomial logistic regression: associations with diminishment and exaggeration compared to 'no change in exposure response' from Baseline (B) to Follow-up 1 (F1) $N = 356$.

	Descriptive N (%)	Diminishment			Exaggeration		
		OR	p -value	95%CI	OR	p -value	95%CI
Gender (males vs females)	Males: 85 (23.88%)	1.01	.983	0.54–1.89	1.54	.180	0.82–2.91
Age [^]	35.42 $\pm$ 11.83	0.99	.481	0.97–1.01	0.99	.613	0.97–1.02
Profession (clinical vs nonclinical)	Clinical: 268 (75.28%)	1.97	.033*	1.06–3.68	1.07	.840	0.58–1.97
ASD Diagnosis at wave 1	86 (48.31%)	1.65	.212	0.75–3.63	1.09	.835	0.47–2.54
ASD Diagnosis at wave 2	97 (31.29%)	1.09	.801	0.57–2.05	1.39	.326	0.72–2.67
ASD Severity at wave 1 [^]	52.37 $\pm$ 16.52	1.02	.067	0.99–1.05	0.99	.979	0.97–1.03
ASD Severity at wave 2 [^]	44.75 $\pm$ 16.03	1.01	.162	0.99–1.03	1.01	.177	0.99–1.03
Self-reported PTSD at wave 3	92 (25.84%)	1.40	.316	0.73–2.70	1.84	.075	0.94–3.59
Self-reported PTSD Severity at wave 3 [^]	22.4 $\pm$ 15.70	1.02	.065	0.99–1.04	1.02	.041*	1.001–1.04
Six Symptoms self-reported PTSD at wave 3	158 (46.47%)	1.89	.145	0.82–3.33	2.26	.007*	1.25–4.07
Majority self-reported PTSD at wave 3	155 (45.59%)	1.52	.145	0.87–2.66	1.96	.024*	1.09–3.51
Depression at wave 3 [^]	5.39 $\pm$ 5.12	0.99	.732	0.93–1.05	1.03	.369	0.97–1.09

Note. * $p < .05$; [^]mean $\pm$ SD.

= [1.001–1.04]). Moreover, fulfilling the diagnostic criteria of subthreshold self-reported PTSD, both Six Plus subthreshold self-reported PTSD and Majority subthreshold self-reported PTSD, showed a significant solid association with exaggeration (Six Plus OR = 2.26, p -value = .007, 95%CI = [1.25–4.07]) (Majority OR = 1.96, p -value = .024, 95%CI = [1.09–3.51]).

3.2.2. Associations with diminishment

Being a clinical professional was significantly associated with later diminishment of trauma exposure (OR = 1.97, p -value = .033, 95%CI = [1.06–3.68]). Moreover, having higher self-reported ASD symptoms (ASD severity) and specifically in wave 1 may be associated with diminishment of recall of exposure at follow up, however, the results were only borderline significant (OR = 1.02, p -value = .067, 95%CI = [0.99–1.05]).

Secondary to the marginal significance in self-reported ASD severity, we further investigated which of all the self-reported ASD symptoms in wave 1 are related to the exposure diminishment (Supplementary Table 4). Out of all the symptoms, we found that item 6 (having memories of the trauma kept entering your mind), item 7 (having had bad dreams or nightmares about the trauma), and item 9 (feeling very upset when

you are reminded of the trauma) which all are intrusion symptoms, at baseline (B) are significantly associated with diminishment at Follow up 1 (F1) 6–7 months later with ORs of 1.41, 1.46 and 1.39, p -values 0.038, 0.012, 0.046, and 95%CI of [1.02–1.95] [1.08–1.97] [1.01–1.94] respectively.

3.3. Participants followed up from baseline to follow-up 2 (Table 4)

In total, 264 participants were followed up from baseline to follow-up 2.

We had complete data on 210 participants on sociodemographic factors, the exposure inventory and the mental health disorders (see Table 4 for descriptive statistics), out of whom 23 (10.95%) had the same response, 91 (43.33%) reported diminishment and 96 (45.71%) reported exaggeration.

3.3.1. Associations with exaggeration

As shown in Table 4, higher scores of self-reported PTSD were significantly associated with exaggeration of trauma exposure (OR = 1.07, p -value = .003, 95%CI = [1.03–1.13]). Having either of the two subthreshold self-reported PTSDs (six plus or majority) was also highly associated with trauma exaggeration

Table 4. Multinomial logistic regression: associations with diminishment and exaggeration compared to 'no change in exposure response' from Baseline (B) to Follow-up 2 (F2) $N = 210$.

	Descriptive N (%)	Diminishment			Exaggeration		
		OR	p -value	95%CI	OR	p -value	95%CI
Gender (males vs females)	Males: 27 (18.75%)	0.50	.217	0.16–1.51	0.34	.074	0.10–1.11
Age [^]	38.83 $\pm$ 12.03	1.01	.607	0.96–1.07	1.01	.618	0.96–1.07
Profession (clinical vs nonclinical)	Clinical: 101 (70.14%)	3.76	.040*	1.06–13.28	3.71	.044*	1.03–13.28
ASD Diagnosis at wave 1	42 (40%)	1.66	.564	0.30–9.18	2.57	.274	0.47–13.94
ASD Diagnosis at wave 2	40 (21.98%)	2.71	.206	0.58–12.77	3.17	.143	0.68–14.81
ASD Severity at wave 1 [^]	49.30 $\pm$ 15.9	1.02	.549	0.97–1.07	1.03	.282	0.98–1.08
ASD Severity at wave 2 [^]	41.57 $\pm$ 15.22	1.02	.382	0.98–1.05	1.02	.384	0.98–1.05
Self-reported PTSD at wave 4	23 (10.95%)	1.01	.992	0.11–9.51	5.08	.124	0.64–40.17
Self-reported PTSD Severity at wave 4 [^]	22.31 $\pm$ 15.09	1.01	.787	0.78–1.08	1.07	.003*	1.03–1.13
Six Symptoms self-reported PTSD at wave 4	83 (44.62%)	1.89	.257	0.63–5.71	4.13	.011*	1.39–12.27
Majority self-reported PTSD at wave 4	54 (28.88%)	2.65	.219	0.56–12.51	6.27	.018*	1.37–28.63
Depression at wave 4 [^]	5.24 $\pm$ 4.41	1.15	.101	0.97–1.37	1.26	.008*	1.06–1.49
Anxiety at wave 4 [^]	4.89 $\pm$ 4.45	1.16	.082	0.98–1.36	1.20	.030*	1.02–1.41

Note. * $p < .05$; [^] Mean $\pm$ SD.

(Six Plus OR = 4.13, p -value = .011, 95%CI = [1.39–12.27]) (Majority OR = 6.27, p -value = .018, 95%CI = [1.37–28.63]). Having higher scores of anxiety were associated with exaggeration as well (OR = 1.20, p -value = .030, 95%CI = [1.02–1.41]).

3.3.2. Associations with diminishment

When inspecting recall from baseline to follow-up 2, being a clinical professional compared to non-clinical professional was consistently significantly associated with diminishment of trauma exposure (OR = 3.76, p -value = .040, 95%CI = [1.06–13.28]).

4. Discussion

According to the existing literature, forgetfulness of trauma could be hypothesised to result from normal forgetting, cognitive avoidance, or impaired encoding as a result of heightened arousal and narrowed attention at the time of trauma (Bryant & Harvey, 1997; Harvey et al., 1998; Moulds & Bryant, 2002; Moulds & Bryant, 2005).

Our findings of self-reported acute intrusive symptoms initially being associated with diminished recall over time relative to those initial reports of exposure may be interpreted in terms of participants over consolidating memories of the blast and its aftermath in the initial period after the trauma. This accords with biological theories that noradrenergic release at the time of extreme trauma contributes to memory over consolidation (Pitman et al., 2000). It is possible that more frequent intrusive memories and nightmares contributes to ongoing reconsolidation of the memory, which enhances survivors' initial reports of the exposures (Moore & Roche, 2007). It is also possible that greater intrusive symptoms in the acute phase contributed to more negative appraisals of events immediately after the blast, and this resulted in greater endorsement of items on the traumatic event checklist. This interpretation is consistent with evidence that people with ASD have a bias to negative appraisals (Warda & Bryant, 1998).

The findings that later self-reported PTSD severity was associated with exaggeration of memory are in line with Roemer et al. who studied war veterans, and Giosan et al., who studied 9/11 restoration workers: more severe PTSD was associated with amplified memories of trauma (Giosan et al., 2009; Roemer et al., 1998). There are many potential explanations to why the severity of self-reported PTSD positively correlates to exaggeration. First, the Beirut Blast was a unique and tragic event, that the media covered extensively for a prolonged period, including ongoing movies, memorials, and stories. This exposure, in addition to conversations with other victims, could have contributed to the exaggeration of memories. Second, there is much evidence of mood

impacting the positive or negative valence of past events (Bower, 1981), and it is likely that as symptom severity increased over time, participants made more negative appraisals about their exposure that were consistent with their current symptom levels.

Our results were extended to include subthreshold definitions of self-reported PTSD, which confirms the necessity to assess the spectrum of symptoms that might be pointing to parallel entities and not strictly the DSM-5 diagnosis of PTSD. Both subthreshold self-reported PTSD diagnoses that we used were associated with exaggeration. It is to be noted that this study represents the very first examination of the relationship between subthreshold self-reported PTSD and memory recollection, making it a novel and pioneering investigation in this area. The unique characteristics of subthreshold self-reported PTSD, such as intermittent symptom manifestation and fluctuating distress levels, may contribute to a higher likelihood of exaggeration as a compensatory mechanism for the recognition of their distress, which might not be as evident or validated as it is in full self-reported PTSD cases.

Furthermore, individuals with subthreshold self-reported PTSD may be more inclined to emphasise their symptoms in an effort to communicate the severity of their experiences, which could explain the association with exaggeration observed in our study. In contrast, those with a full self-reported PTSD have a well-defined and recognised symptomatology, potentially reducing the need to exaggerate their symptoms. Third, it is possible that reexperiencing the trauma through nightmares, flashbacks, and intrusive memories gradually begin to recall the traumatic event. In fact, Koenen et al. stated that increases in reexperiencing symptoms predicted increases in exposure reports (Hirst et al., 2009).

Profession was shown to be associated with lower trauma recollection; it was evident that clinical professionals (including nurses, doctors, residents, laboratory technicians, radiologists, and dietitians etc.) diminished their exposure more than non-clinical professionals (including admission and patient's account, budget department, environmental services, finances, information desk, general services, human resources, medical engineering, material management, and laundry etc.). Recovering from traumatic experiences depends largely on the search for meaning, as supported by a large body of literature (Herman, 1992). Clinical professionals may be diminishing their trauma exposure unconsciously to help reimburse their role as 'heroes' in this crisis, giving them more meaning and a defense mechanism to deal with their trauma: sublimation. Another potential explanation is the resilience of healthcare professionals, which, although multifaceted, can be defined as 'positive adaptation to adversity'. Resilience

was found to be significantly associated with traits necessary for the high function level of the demanding roles of healthcare professionals (Robertson et al., 2016). In fact, the Beirut Blast occurred after the COVID-19 pandemic had been in Lebanon for 6 months. During the early waves, managing more than 50 patients with COVID-19, working long shifts, being involved with families in end-of-life decisions, providing intensive care, were all associated with more resilience (Azoulay et al., 2024). This could have prepared them to better handle the later trauma which is the blast, using coping mechanisms.

Since the population in question is 'contained' within a single geographical area, we thought that a prospective study would be ideal to ensure a good follow up of a diversity of health workers, but this jeopardised generalizability of the findings. Although we were able to retain a high response rate in our follow up recruitment through email, yet it is possible that many of the non-responders had PTSD and wanted to avoid the subject. However, this was not verified. On the other hand, diminishment of recall did not seem to be related to the reaction to the trauma beyond the first couple of weeks of trauma; where having self-reported Acute Stress Reaction in the first couple of weeks after trauma (9–15 days: wave 1 of baseline) was associated with diminishment of recollection up to six months; more specifically, the intrusion symptoms of self-reported ASD were found to be related to diminishment of recollection. However, this relation was not substantiated again in wave 2 of baseline which was less than 1 month (21–27 days) post trauma. Additionally, this study serves as an initial exploration of subthreshold self-reported PTSD and self-reported ASD symptoms as associations with recall bias with a limited sample size. Further research with larger cohorts is necessary to confirm and extend our findings. Finally, all our data was secondary to self-reporting instrument which reflect a proxy diagnosis of the DSM-5.

With the above limitations, our findings are quite telling: repeatedly and over several phases spanning more than 2 years, the presence of self-reported PTSD and its subthreshold varieties are associated with exaggerated recall. This was found repeatedly over every phase of our prospective follow up study. Anxiety too had the same effect although only measured in the last wave, 2 years after exposure. Is it the constant state of alertness or the constant ruminations that adorn more and more the tree with additional aspects of the trauma over time? Additionally, to our knowledge, our study is the only study with two time point assessment of self-reported ASD within one month and with recall bias studied secondary to a real and not experimentally-induced trauma where self-reported acute stress disorder was shown to be associated with diminishment of recall.

This study's findings have potential implications for treatment. The fact that the memory of traumatic events often shifts over time raises the possibility that the quest for historical 'truth' may be complicated. Sometimes, the memories that trauma survivors describe now don't seem to match their earlier recollections of the same incidents. Thus, therapists' attempts to find the 'truth' may not be what they think it is. Since the 'real' version of the past might no longer exist, it might make more sense from a psychotherapy standpoint to deal with the patient's current version of events. Additionally, during psychotherapy, it is possible that the intensity of symptoms will alter, leading to a change in traumatic memories. Future research has the potential to address many matters complimentary to this study. While there are many studies that document the inconsistency of recall of traumatic memories, the literature concludes with assumptions and suggestions as to why. Instead, after recognising the discrepancy, it would be a good idea to ask the participants themselves why they think their answer changed.

Author contributions

E.K.: conception and design, the drafting of the paper, the final approval of the version to be published; J.B.: conception and design, analysis and interpretation of the data, the drafting of the paper, the final approval of the version to be published; F.H.: the drafting of the paper, the final approval of the version to be published; F.M.: revising it critically for intellectual content, the final approval of the version to be published; E.S.: revising it critically for intellectual content, the final approval of the version to be published; R.B.: revising it critically for intellectual content, the final approval of the version to be published. All authors agree to be accountable for all aspects of the work.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Informed consent

The patients provided oral informed consent to participate in the research.

Data availability statement

Due to the nature of the research, supporting data is not available for ethical reasons.

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