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INTRUSIVE MEMORIES OF TRAUMA: A CLINICAL TARGET

Veronika Kubičková

A thesis submitted in partial fulfilment of the requirements of the degree of Doctor of Clinical Psychology, validated by the University of Oxford

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INTRUSIVE MEMORIES OF TRAUMA: A CLINICAL TARGET

Veronika Kubičková, Harris Manchester College, University of Oxford, Doctorate in Clinical Psychology, August 2021

Executive summary

Background: Intrusive memories of traumatic events are distressing, vivid memories which come into the mind involuntarily, and comprise a core symptom of posttraumatic stress disorder (PTSD). Intrusive memories are a common consequence of frontline work among healthcare staff where exposure to traumatic events is unavoidable. There is a need to understand the functional implications of experiencing intrusive memories and to develop and evaluate effective treatments targeting intrusive memories to support the mental wellbeing of healthcare staff. **Objectives:** The objectives of this research thesis were twofold. First, to systematically review and synthesise the literature investigating the relationship between intrusive memories of trauma and functioning. Second, to investigate the effectiveness of a brief cognitive task intervention on the number of intrusive memories, general functioning, and mental health symptoms among healthcare staff. Feasibility and acceptability of the intervention was also assessed. **Methods**: To address the first objective, functioning was operationalised using domains of the WHO International Classification of Functioning, Disability and Health (ICF). Systematic searches of peer-reviewed journal articles were conducted using search terms related to PTSD and intrusive memories. To investigate the second objective, a case series using an AB single-case experimental design was employed. **Results**: From the seventeen studies reviewed, a relationship was found between intrusive memories and functioning impairments across multiple subcategories of the ICF, including sleep, concentration, rumination, and activities of daily living. The empirical study found an overall significant reduction in the number of intrusive memories

from baseline to post-intervention. Improvements in functioning and mental health symptom reductions were reported. The intervention was generally feasible and acceptable to staff. **Conclusions**: Trauma-related intrusive memories are associated with impairments across several domains of functioning. Preliminary findings suggest that a brief cognitive task intervention could provide means to mitigate the impact of work-related traumatic events among healthcare staff.

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Paper A

A Systematic Review of the Relationship between Intrusive Memories of Trauma and Functioning

Veronika Kubičková

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(See Appendix 1 for author guidelines)

Abstract

Introduction: Intrusive memories of traumatic events are vivid emotional memories that come into the mind unbidden and represent a core symptom of posttraumatic stress disorder (PTSD). Impairments in functioning associated with PTSD are well documented in the literature. Although intrusive memories have been identified as highly distressing and a possible driver of symptom severity, the relationship between intrusive memories and functioning has not yet been comprehensively reviewed. **Objective:** This review aimed to synthesise the research investigating associations between intrusive memories and functional impairment, as described by the WHO International Classification of Functioning, Disability and Health (ICF). **Method:** Inclusion criteria comprised peer-reviewed studies relying on observational and experimental methodology. Studies were included if they documented intrusive memories as part of a PTSD assessment or trauma-related intrusive memories occurring independent of mental health diagnoses. Both real-life and experimentally induced analogue trauma studies were included. No restrictions were placed on date of publication. Functional impairments were categorised according to the ICF. **Results:** A total of seventeen studies comprising 12,229 participants were reviewed. Fifteen studies found intrusive memories to be associated with functioning impairment across subcategories of two ICF domains: *Body Functions* and *Activities and Participation*. Areas identified included sleep, concentration, emotional functions, levels of stress, rumination, and activities of daily living. **Conclusions:** Trauma-related intrusive memories were associated with several areas of daily functioning as conceptualised by the ICF and were related to functioning even outside of a mental health diagnosis. The development of targeted interventions for intrusive trauma-related memories would therefore seem justified. **Word count: 250**

Introduction

Intrusive memories of trauma

Intrusive memories of traumatic events are sensory (Ehlers et al., 2005), involuntary and vivid (Grey & Holmes, 2008), occurring when past memories intrude upon the present (Iyadurai et al., 2019). When they are experienced three days to one-month post-trauma, they are understood to be a symptom of Acute Stress Disorder (ASD). If they last beyond this time, they are regarded as a cardinal symptom of the re-experiencing cluster within post-traumatic stress disorder (PTSD; American Psychiatric Association [APA], 2013). Intrusive memories are distressing in their own right (Ehlers & Steil, 1995), and thought to drive PTSD symptom development and maintenance through over-consolidation of trauma memory (Bryant et al., 2017). Although event-related intrusive memories are a core manifestation of PTSD, they also occur in sub-threshold and non-clinical populations, as well as several other psychological disorders (Bryant et al., 2011). In the early aftermath of trauma, intrusive memories are a common occurrence, and not immediately an indication of pathology (Ehlers, 2010). Indeed, the frequency and distressing nature of intrusions reduces over time (Iyadurai, 2019). It is therefore not unusual for intrusive memories to resolve spontaneously for most people. For example, in a sample of motor vehicle accident patients, 76% had intrusive memories immediately after the accident. This dropped to 25% in the 3 months following the accident and plateaued to 24% a year later (Mayou et al., 1993). The impact of intrusive memories experienced in the acute phase after a traumatic event compared to those experienced one-year post-trauma might be considerably different; not least when considering the effect of a repeated distressing sensory memory over a long period of time. The development and maintenance of intrusive memories is now better understood, for example, the critical role that pre- and post-event negative appraisals, and higher data-driven processing play (Marks et al., 2018). However, the impact of intrusive memories on daily

functioning, and whether impairment occurs only in populations diagnosed with PTSD, remains largely unknown. Improving the recognition and understanding of the impact of persistent intrusive memories is key to alleviating their cognitive and psychosocial burden and is therefore an important next step.

Defining functioning

According to the World Health Organisation (WHO) International Classification of Functioning, Disability and Health (ICF), *functioning* is defined as "all body functions, activities and participation" whilst *disability* pertains to "impairments, activity limitations and participation restrictions" (WHO, 2002, p. 2). The ICF is used as a framework for measuring functioning, health and disability among populations utilising an integrated biopsychosocial model of human functioning. It comprises four domains: *Body Functions* (domain '*b*'); *Activities and Participation* (domain '*d*'); *Environmental Factors* (domain '*e*') and *Body Structures* (domain '*s*'; WHO, 2002). The WHO framework has been used by previous research in the field of trauma to define functioning (e.g., Jellestad et al., 2021). The rationale for using the ICF as a framework to identify possible functional impairments associated with trauma-related intrusive memories was two-fold: 1) its multi-faceted domains encompass aspects of functioning which are more specific and span above and beyond those captured by the functioning impairments listed in the DSM-5 diagnostic criteria for PTSD. For example, 'd2400 Handling responsibilities' within domain d2, General Tasks and Demands, or 'd470-d489 Moving around using transportation' within domain d4 Mobility. Thus, as this was the first time a synthesis on the relationship between functioning and intrusive memories was carried out, it was important to keep the facets of functioning as broad and as specific as possible; 2) the ICF provides an internationally recognised structure within which to organise aspects of functioning, thus improving comparability across studies. Table 1 provides domain

definitions and categorisations as well as specific examples of areas of functioning included under each domain.

Table 1. International Classification of Functioning, Disability and Health domains and subcategories as well as specific examples of areas of functioning included under each domain, adapted from the World Health Organisation (WHO, 2002).

Domain '*b*': *Body Functions*	**Domain '*d*': *Activities and Participation***
Defined as physiological and psychological functions of body systems.	*Activity* is understood as the execution of a task or action by an individual, and *Participation* is involvement in a life situation.
b1 Mental Functions	
b2 Sensory Functions and Pain	d1 Learning and Applying Knowledge
b3 Voice and Speech Functions	d2 General Tasks and Demands
b4 Functions of the Cardiovascular, Haematological, Immunological and Respiratory Systems	d3 Communication
	d4 Mobility
	d5 Self-Care
b5 Functions of the Digestive, Metabolic, Endocrine Systems	d6 Domestic Life
	d7 Interpersonal Interactions and Relationships
b6 Genitourinary and Reproductive Functions	d8 Major Life Areas
b7 Neuromusculoskeletal and Movement-Related Functions	d9 Community, Social and Civic Life
b8 Functions of the Skin and Related Structures	
This includes areas of functioning such as: motivation, sleep, concentration, and emotional functions such as anger or sadness.	This includes areas of functioning such as: decision-making, handling stress, relationships and interactions with others, self-care, mobility, and work and employment.
Domain '*s*': *Body Structures*	**Domain '*e*': *Environmental Factors***
Defined as anatomical parts of the body such as organs, limbs and their components.	Comprise physical, social and attitudinal environment in which people live and conduct their lives.
s1 Structures of the Nervous System	
s2 The Eye, Ear and Related Structures	e1 Products and Technology
s3 Structures Involved in Voice and Speech	e2 Natural Environment and Human-Made Changes to Environment
s4 Structures of the Cardiovascular, Immunological and Respiratory Systems	
	e3 Support and Relationships
	e4 Attitudes
s5 Structures Related to the Digestive, Metabolic and Endocrine Systems	e5 Services, Systems and Policies
s6 Structures Related to the Genitourinary and Reproductive Systems	
s7 Structures Related to Movement	
s8 Skin and Related Structures	
This includes areas of functioning such as: structure of the brain, structure of the cardiovascular system, and structures related to movement.	This includes areas of functioning such as: climate, physical geography, assistive products and technology for mobility and transportation, and individual attitudes of immediate family members.

Functional impairment and PTSD

There is compelling evidence for functional impairment in PTSD which has been well documented in the literature (e.g., Davidson, 2000). A recent meta-analytic review which examined functional impairment in PTSD found that individuals with a diagnosis of PTSD compared to healthy subjects showed significant impairments in all ICF subcategories of domain *d Activities and Participation* with large to very large effect sizes. Similarly, individuals with PTSD compared to clinical controls showed impairments in all but two subcategories (*d1* and *d3*) of the same domain with medium to large effect sizes (Jellestad et al., 2021). There is also specific evidence for the relationship between the re-experiencing cluster of PTSD and functional impairment. In a sample of trauma-exposed war veterans, the re-experiencing cluster was associated with global functional impairment (Meyer et al., 2018). Sleep difficulties, which are considered an aspect of functional impairment according to the ICF, are also a frequent consequence of PTSD and impact on workplace performance and daily functioning (Vandrey et al., 2014). Among 9/11World Trade Centre responders, the effects of sleep duration on PTSD were largely driven by re-experiencing symptoms (Dietch et al., 2019). Individuals who are classified in the sub-threshold category of PTSD were also identified to suffer significant psychosocial impairment (Ballenger et al., 2000). As individuals in the sub-threshold population also experience intrusive memories (Ehlers, 2010), studying the impact of intrusive memories on functioning separate to a diagnostic category is therefore necessary. Despite the plethora of evidence for functional impairment associated with PTSD and the re-experiencing cluster as a whole, to date, no synthesised account of the relationship between intrusive memories and these impairments exists. This is important to investigate to inform which symptom to target first, so that individual treatment gains can be maximised.

Functional impairment and trauma-related intrusive memories

What symptoms, or constellation of symptoms, in PTSD drive functional impairment is an ongoing debate in the literature (e.g., Norman et al., 2007). For example, at the centre of the cognitive model of PTSD lies the notion of the activation of a strong perception of current threat, of which intrusive memories and several behavioural and cognitive responses are a consequence, may drive impairment (Ehlers & Clark, 2000). Moreover, understanding the unique contributions of individual PTSD symptoms such as intrusive memories is that much more challenging given that rates of co-morbidity in PTSD (especially with major depression and other anxiety disorders) are very high, and they compound social and occupational functioning impairments (Breslau, 2002; North et al., 1999; Schnurr et al., 2000). Further, there is growing evidence for differences in the way that PTSD symptoms are experienced across cultures. For example, Hispanic individuals reported more positive symptoms (e.g., intrusive symptoms, hyper-vigilance) compared to negative symptoms (emotional detachments, restricted affect; Trepasso-Grullon, 2013), thus, it may be reasonable to postulate that functional impairments too, may in turn fluctuate. Indeed, some studies have demonstrated, that whilst re-experiencing symptoms were universal, it was the numbing and avoidance symptoms which were more significant in their contributions to the level of functional impairment (Foa et al., 1995; North et al., 1999; Rona et al., 2009).

The trauma literature also suggests, however, that intrusive memories have a wide spanning impact across several domains of cognitive, interpersonal, social and occupational functioning. For example, intrusive memories have been found to be related to disruptions in concentration (Holmes et al., 2017), difficulties falling asleep and maintaining sleep (Luik et al., 2019), and stress levels (Kanstrup et al., 2020). Intrusive memories of trauma have been postulated by cognitive models of PTSD as a potential driver of the other three categories of PTSD symptoms (avoidance, hyperarousal and changes in cognition and mood; Brewin,

2014; Ehlers & Clark, 2000), which further underscores the need to understand the impact that intrusive memories can have on individuals' functioning to help tackle the multi-faceted burden of trauma. For example, it has been found that when intrusive memories of trauma 'invade' the mind, they can 'hijack' one's attention, overriding selective attention (Clark & Mackay, 2015). Thus, understanding whether a special relationship between intrusive memories and functioning does indeed exist, is an important next step.

Existing treatments for PTSD target the disorder globally, and thus work with the alleviation of multiple symptoms. There has been a recent call for the development of PTSD treatments targeting individual aspects of the disorder (Hoge & Chard, 2018). This 'precision approach' allows for the examination of cognitive processes in isolation and under controlled conditions (Iyadurai et al., 2019). Importantly, it enables the examination of the implicated functional impairment associated with this single symptom, which is essential for effective interventional targeting.

Objective of this review

This review aimed to synthesise the research investigating associations between intrusive trauma memories and functional impairment, as defined by the WHO ICF (WHO, 2002). Specifically, this review considered studies where intrusive memories and functioning were measured at a single timepoint allowing for an exploration of how these two factors relate, or where a direct predictive relationship between intrusive memories (measured at timepoint one) and functioning outcomes (measured at timepoint 2 or beyond) was established. Studies which reported a reverse direction were not included in this review. This approach to causality allows for the synthesis of studies exploring a relationship between intrusive memories and functioning as well as the direct impacts intrusive memories have upon functioning, however, it limits the understanding of the way in which functioning may

specifically impact upon intrusive memories. The specific remit of this review was to consider trauma event-related intrusive memories as a symptom in isolation in PTSD, subthreshold PTSD and non-clinical populations.

Method

The methodology for this review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Liberati et al., 2009) process.

Protocol and registration

This review protocol was registered with the international prospective register of systematic review (PROSPERO) on 20th April 2021 prior to data extraction, quality assessment, data analysis and synthesis. The protocol can be found at: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=228779

Search strategy and information sources

Studies were identified by systematically searching PsycINFO, Medline and PubMed up to March 2021. The following classification concepts were included as the topic search terms: the condition (e.g., trauma; 'post-traumatic stress disorder') and the specific symptom (e.g., 'intrusive memor*'; 'involuntary recollection*'). Specific thesaurus terms were used per database. See Appendix 2 for a full electronic search strategy. This review conducted forward and backward citation title searches on the included articles. Reference lists of systematic reviews identified in the search were also reviewed for potentially relevant articles.

Study selection process

Journal articles were screened against the criteria outlined below. One reviewer (VK) screened article titles and abstracts utilising the PICOS methodology (Liberati et al., 2009):

- Population: human study, adults aged 18 year or over, individuals who are experiencing trauma-related intrusive memories.
- Intervention/exposure: individuals whose intrusion symptoms were measured following exposure to a traumatic event or experimentally induced trauma analogue.
- Comparator: this review did not require studies to have a comparator
- Outcome: measure of functioning.
- Study design: either a) study designs where there are multiple time points of measurement e.g., prospective correlational, longitudinal, experimental (e.g., RCT), case series, or b) single time point studies, e.g., cross-sectional studies.

Based on this search strategy, studies were either included for full-text screening if all of the above criteria were met, excluded if not all criteria were met, or rated as 'unsure' and thus required full-text screening to determine eligibility (see Appendix 3 for a bespoke screening and selection tool). If clarity around inclusion was not reached after full-text screening, a second reviewer was consulted (FW).

Eligibility criteria

For the purpose of this review, intrusive memories were defined broadly as sensory memories comprising images and thoughts which come to mind involuntarily (e.g., Ehlers et al., 2005; Grey & Holmes, 2008). Therefore, studies that defined intrusive memories as both 'visual images' and 'thoughts' were included. However, studies that assessed only intrusive thoughts (i.e., not linked to an event) were excluded, given that they are postulated to constitute a separate construct in the literature (Hagenaars et al., 2010). Although widely recognised in the literature as a transdiagnostic symptom (Brewin et al., 2010; Holmes & Mathews, 2010), this review included studies reporting on intrusive memories of trauma-related events which were either experimentally induced or that developed following real-life

trauma exposure. Hence, to explore the impact across a trauma continuum, this review considered populations without a known ASD/PTSD diagnosis, those meeting sub-clinical threshold criteria and individuals for whom intrusive memories feature a cardinal symptom of psychopathology, including ASD and PTSD. Where intrusive memories were considered part of a diagnosis of PTSD or ASD, only studies analysing intrusive memories as a single symptom of that diagnosis were considered, i.e., not part of the re-experiencing PTSD cluster as defined by the DSM-5 (APA, 2013). The rationale for this is that the re-experiencing cluster of PTSD, and the existing psychometric measures used to assess this cluster symptoms, include phenomena such as dreams and intrusive thoughts, which are regarded as a separate constructs to intrusive images (Hagenaars et al., 2010). There were no constraints applied to the methodology of intrusive memories measurement. Measures of severity, frequency, distress or vividness were all acceptable. Studies which included valid and reliable measures of intrusive memories (e.g., items from the Intrusion subscale of the IES-R (Weiss & Marmar, 1997) as well as idiosyncratic rating scales (e.g., Likert-style rating scale of intrusive memory distress) were included. To date there is no synthesised evidence regarding the associations between functioning and intrusive memories, therefore the current review included a wide range of study designs[1]. Studies where intrusive memories and functioning were measured at the same timepoint or where intrusive memories were measured at time 1 (T1) and functioning at time 2 (T2; or beyond) were included. However, studies where there was a direct predictive relationship between functioning outcomes and intrusive memories, for example where the analysis or design are such that functioning is measured at T1 and intrusive memories at T2 (or beyond), were not included. Studies employing qualitative

[1] Study designs were determined based on the way in which exposure and outcome relevant to the research question were measured and not the overall study design, e.g., an experimental study where intrusive memories and functioning were measured at T1 would be classified as an observational cross-sectional study.

methods were excluded. Only peer-reviewed journal articles published in English were included. There were no time constraints applied on the published literature.

For the purpose of this review and to improve comparability across studies, 'functioning' was defined according to the WHO ICF (WHO, 2002; see Appendix 4 for a comprehensive guide to the ICF) and included studies where outcomes related to the measurement of severity or changes in functioning. Studies where functioning was not measured separately from a PTSD symptom cluster, e.g., hyperarousal symptom cluster which includes difficulty sleeping, were not included. The rationale for this was that including a whole PSTD symptom cluster did not allow the examination of the relationship between *individual* functioning constructs and intrusive memories. See Appendix 5 for a summary of the inclusion and exclusion criteria.

Data extraction

A data extraction tool was developed according to guidance for conducting systematic reviews from the Cochrane handbook (Higgins et al., 2019). The information extracted included author(s), year of publication, participant demographics, (e.g., mean age (SD), gender), total trauma-exposed sample size, type of trauma exposure (e.g., military, natural disaster), assessment schedule (time points of assessment), type of study (e.g., cohort, cross-sectional), assessment of intrusive memories (e.g., frequency, distress, vividness), ICF domain (e.g., *d4 Mobility*), outcome variable assessment (i.e., type of functioning measure), statistical analyses, study aims, and study findings.

Risk of bias assessment

The study quality and risk of bias were assessed using the National Institute for Health (NIH) quality assessment tools (National Institute for Health, National Heart, Lung, and Blood Institute, n.d.). Given that this review considered multiple study designs, the

specific quality assessment tool, which most closely described the type of study, was used[2]. See Appendix 6 for the NIH study-specific tools relevant to the included study designs used for this review, including the criteria against which studies were judged. The aim of the risk of bias assessment was to consider the strengths and weaknesses of the included studies to determine their overall contribution to the conclusions that can be drawn about the associations between intrusive memories and functioning. Studies were assigned a quality rating of 'good', 'fair', 'poor' based on the outcomes of the NIH quality assessment tool criteria and the contribution to answering the research question.

Synthesis process

There was a significant level of heterogeneity among conceptual (functioning domain classification and intrusive memory definition) and methodological (outcome measures used and the associated quality) factors. It was deemed appropriate that a narrative review and synthesis was conducted without quantitative meta-analysis. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009; Appendix 7) and the synthesis without meta-analysis guidelines (SWiM; Campbell et al., 2020, Appendix 8) were used to guide the synthesis process. Only analyses and findings relevant to the research objective are reported and discussed. Studies were synthesised according to a) different ICF domains and b) whether the study was a diagnostic assessment study (i.e., diagnosis was pre-specified in study inclusion criteria or assessed for during the study) or symptom-only study (i.e., intrusive memories assessed outside of a diagnostic category). The synthesis of quality was guided by quality themes rather than evaluations of

[2] National Institute for Health (NIH) quality assessment tools include: 'Quality Assessment of Controlled Intervention Studies', 'Quality Assessment of Observational Cohort and Cross-Sectional Studies', 'Quality Assessment of Case-Control Studies', 'Quality Assessment Tool for Before-After (pre-post) Studied with No Control Group' and 'Quality Assessment of Case Series Studies'.

individual studies. Results were prioritised based on the number of studies categorised under each ICF domain and the overall quality of those studies.

Reliability and peer-review checks

Two independent peer-reviewers were involved at two stages of the reliability checking process of this review. Firstly, at the stage of title, abstract and full-text screening, a peer-reviewer (FW) conducted reliability checks on 20% (152 of 761) of randomly selected papers. For 18 of the 152 studies (12%), discrepancies in opinions arose. For one study (<1%) where the researcher indicated it ought to be included, the peer-reviewer stated 'unsure and full text screen required'. For fourteen studies (9%), the researcher indicated 'unsure and full screen required', whilst the peer-reviewer indicated they ought to be excluded. There were three studies (2%) where the researcher excluded them, whereas the peer-reviewer indicated that the full text ought to be reviewed. The full text of these three studies was subsequently reviewed by the researcher and excluded due to not meeting the study eligibility criteria. Please refer to Figure 1 below for details. Secondly, a peer-reviewer (EB) assessed the quality and risk of bias of 29% (five out of seventeen) of the included studies. Differences in opinion were predominantly relating to whether items on the quality appraisal tool met the conditions partially. Discrepancies in judgement on whether individual quality criteria within the quality assessment tools were met full or partially occurred for 25% of all the quality criteria reviewed for the five studies. The initial discrepancies did not, however, affect the final quality ratings. There was 100% agreement on the final quality rating of the five studies.

Results

Study selection

The initial search returned 1,213 articles. After duplicates were removed, 761 article titles and abstracts were screened for eligibility. Full text screening was carried out on 147 articles. Citation searches returned a further two eligible articles. The final number of studies included in this review was seventeen. Figure 1 shows the study selection process and details reasons for study exclusion.

Sample and study characteristics

Table 2 provides a summary of the sample characteristics of studies in this review. Table 3 summarises the classification of functioning outcomes reported by the included studies within ICF domains. Table 4 presents the study characteristics.

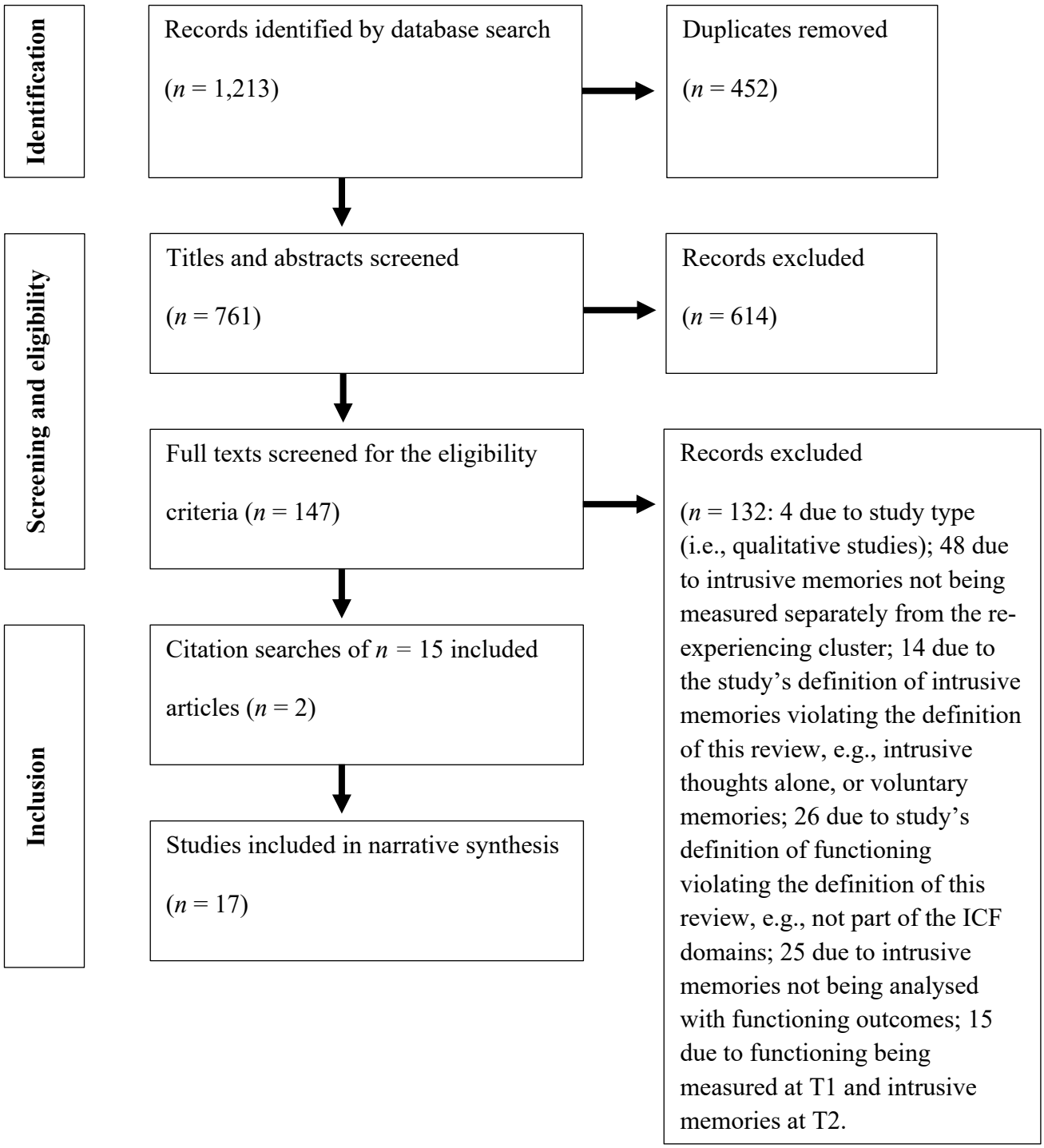


Figure 1. PRISMA flow diagram outlining the study selection process.

Table 2. Sample characteristics.

Study ID, Authors (year)	Group: symptom study v. diagnostic assessment study	Sample	Trauma type	*M* age (SD/%/range)	Gender: female (%)	Sample size per timepoint	Assessment schedule
1 Alsawy et al., (2015)	Symptom study	Adults living in private households	NS	16–24 years (7.7%), 25–34 years (14.0%), 35–44 years (19.0%), 45–54 years (15.3%), 55–64 years (17.3%), 65–74 years (13.9%), 75 or above years (12.8%)	56.8%	*n* = 7,403	T1 = one-off assessment
2 Brand et al. (2020)	Diagnostic assessment study (CAPS-5: 39.3% diagnosed with PTSD)	People experiencing auditory hallucinations	Mixed life events	44.96 (9.9)	64.3%	*n* = 28	Multiple timepoints of assessment = 6-day time-based schedule of ecological momentary assessment
3 Briddon et al., (2015)	Symptom study	New mothers	Childbirth	28 (6)	100%	T1 *n* = 122; T2 *n* = 65	T1 = initial assessment; T2 = follow-up at 6 weeks
4 Bryant et al., (2017)	Diagnostic assessment study (CAPS: 9.6% diagnosed with PTSD at 12 months)	Traumatic injury survivors	Mixed traumatic injuries	37.90 (13.6)	26.4%	T1 *n* = 1,138; T2 *n* = 838	T1 = 1-21 days after traumatic injury; T2 = 12 months after initial assessment
5 Evans et al., (2007)	Diagnostic assessment study	Young offenders	Trauma related to	No intrusion group: 19.7	0%	*n* = 105	T1 = one-off assessment

	(measured using PSS-I; 5.7% diagnosed with PTSD)		committing grievous bodily harm; attempted murder; manslaughter; murder	(0.9); Intrusion group: 19.9 (0.9)			
6 Fried et al., (2018)	Diagnostic assessment study (Samples 2 & 4: 100%; sample 1: 67.7%; sample 3: 59.3% diagnosed with PTSD)	Treatment-seeking patients/soldiers/refugees	Civilian-, refugee-, combat-, post-war offspring-, and professional duty-related trauma	Sample 1: 47 (17–74); sample 2: 35.6 (18–61); sample 3: 36.2 (21–76); sample 4: NS (18–79)	Sample 1: 35.9%; sample 2: 72.1%; sample 3: 5.2%; sample 4: 42%	*n* = 2,782 (sample 1 = 526; sample 2 = 365; sample 3 = 926; sample 4 = 965)	T1 = one-off assessment
7 Holmes et al., (2017)	Symptom study	Refugees	Trauma related to the experience of being a refugee	22 (2.4)	22.7%	*n* = 22	T1 = one-off assessment
8 Iyadurai et al., (2019)	Symptom study	University staff and students	NS	18–30 years (56.4%); 31–50 years (33.9%) and over 51 years (9.4%)	66.0%	*n* = 81	T1 = one-off assessment
9 Kanstrup et al., (2020)	Symptom study	Refugees/asylum seekers	Trauma related to the experience	29.4 (11.6)	40.0%	ABAB series: *n* = 4; AB series: *n* = 1	T1 = baseline 'A'; T2 = week 1 intervention 'B'; T3 = baseline 'A'; T4 = week 3

			of being a refugee				intervention 'B'; T5 = final assessment
10 Kanstrup et al., (2021)	Symptom study	People reporting to the emergency department (ED) and the ED walk-in centre	Assaults, transportation accidents, accidents in the community	46.15 (15.8)	56.1%	*n* = 41	T1 = 1-week follow-up; T2 = 1-month follow-up; T3 = 3-month follow-up; T4 = 6-month follow-up
11 Kleim et al., (2013)	Diagnostic assessment study (43.5% diagnosed with PTSD)	Assault and motor vehicle accident (MVA) survivors	Assault and motor vehicle accidents	PTSD group: 37.3 (18.1); Non-PTSD group: 35.6 (13.3)	PTSD group: 60.0%; non-PTSD: 53.8%	*n* = 46	Multiple timepoints of assessment: 7-day monitoring using ecological momentary assessment
12 Kleindienst et al., (2017)	Diagnostic assessment study (100% diagnosed with PTSD)	Interpersonal violence survivors	Interpersonal violence	38.9 (11.6)	83.3%	*n* = 66	T1 = baseline assessment; multiple timepoints of assessment = event-based sampling (EBS) for 3 days; time-based sampling (TBS) for 7 days (at 10am, 12pm, 2pm, 4pm, 6pm, 8pm)
13 Letzter-Pouw & Werner (2005)	Symptom study	Holocaust survivors	NS	77.6 (5.5)	64.6%	*n* = 96	T1 = one-off assessment
14 Luik et al., (2019)	Symptom study	People reporting to the ED	Motor vehicle accidents	39.66 (16.3)	52.1%	*n* = 71	T1 = 1-week follow-up, T2 = 1-month follow-up
15 Ron & Shamai (2011)	Symptom study	Social workers	Professional work with terror victims and	45.50 (1.12)	91.5%	*n* = 406	T1 = one-off assessment

			their families				
16 Ron & Shamai (2014)	Symptom study	Nurses employed in hospital departments	Professional work with terror victims	42.2 (3.74)	63.0%	*n* = 214	T1 = one-off assessment
17 Speckens et al., (2007)	Diagnostic assessment study (100% diagnosed with PTSD)	PTSD patients	Assaults, transportation accidents, accidents in the community	38.3 (11.0)	51.6%	*n* = 31	T1 = one-off assessment

Note: NS = not specified, T1 = time-point one, T2 = time-point two, T3 = time-point three.

Sample

Sample size

Sample sizes were variable and ranged from 4 to 7,403 participants (*Med* = 71, *IQR* = 173) on the final assessment. The total number of participants from all the eligible studies was 12,229.

Age, gender, ethnicity, and location of studies

Where reported, the average age of participants ranged from 19.7 – 77.6 years old. The average age of participants was ≤30 in five studies, ≥31 and <40 in six studies and ≥40 and <50 in four studies and ≥ 50 in two studies. The average gender distribution was relatively even, with 52.7% female participants across studies. There were, however, several studies which had a disproportionate distribution (>80%) of male (5) and female participants (3, 12, 15). The ethnicity of participants was reported in seven studies (1, 2, 3, 5, 11, 14, 17) and ranged from 52% to 92% Caucasian. The studies were conducted across seven countries (Australia, Denmark, Germany, Israel, Netherlands, Sweden and UK). Two studies did not report the location of the study (11, 13).

Study design, sample population and trauma type

There were fifteen observational studies, of which ten were cross-sectional (1, 5, 6, 7, 8, 12, 13, 15, 16, 17), two cohort (3, 4) of which only one was a true prospective cohort (4), one longitudinal (14) and two were ecological momentary assessment (2, 11) studies. Two studies were experimental, one was a randomised controlled trial (RCT; 10) and the other a case series (9). The assessment schedule varied extensively among the studies, with time between baseline and final follow-up ranging between one month and twelve months.

The sample population and trauma types varied between studies. The most common sample type included individuals who sustained physical injuries or accidents (e.g., motor vehicle accidents), or assault (2, 4, 10, 11, 14, 17). Three studies recruited refugees or asylum

seekers (6, 7, 9). Two studies assessed various stressful or potentially traumatic life events which occurred at any point in one's life but did not specify the trauma type (1: Adults living in private households; 8: University staff and students; 13: Holocaust survivors). Two studies targeted professionals, i.e., social workers and nurses, some of whom had encountered traumatic events as part of their daily work (15, 16). One was a birth cohort (3) in which childbirth itself was considered a potentially traumatic experience; one was a group of young offenders (5); a further two studies included individuals who had experienced interpersonal violence (2, 12). Two studies included a military population sample (2, 6). There were no studies reporting on intrusive memories after experimentally induced trauma. The heterogenous nature of trauma being studied may impact the generalisability of the conclusions drawn.

Assessment of posttraumatic stress disorder

Seven studies assessed intrusive memories as a symptom of PTSD or ASD (i.e., 'diagnostic assessment studies') with four conducting a diagnostic assessment of PTSD among their participants (2, 4, 5, 11) and three studies pre-specifying a clinical diagnosis in their inclusion criteria (6, 12, 17). The most commonly used measure to establish a PTSD diagnosis was the Clinician Administered PTSD Scale (CAPS) version for DSM-IV (Blake et al., 1995) and for DSM-5 (Weathers et al., 2013). All but one study establishing a PTSD diagnosis used a validated clinical interview schedule. The exception was a cross-cultural multisite study (6) which analysed four clinical samples, where only one of the samples used a validated clinical interview schedule to establish a PTSD diagnosis (the Structured Clinical Interview for DSM-IV Axis I Disorders; SCID-IV), as part of their routine diagnostic procedure. The other three samples utilised a self-report measure of PTSD symptoms which were the Civilian version of the PTSD checklist (PCL-C; Weathers et al., 1993) and the Posttraumatic Stress Symptom Scale Self-Report (PSS-R; Foa et al., 1997). Studies which

utilised a diagnostic interview based on DSM-5 criteria strengthened the reliability of a PTSD diagnosis and increased confidence in the conclusions drawn from these studies.

Ten studies measured intrusive memories in non-clinical or sub-clinical threshold ASD/PTSD populations (i.e., 'symptom studies'; 1, 3, 7, 8; 9, 10, 13, 14, 15, 16).

Overall study quality

Seventeen studies were assessed for quality and risk of bias using the NIH Quality Assessment Tools (n.d.) corresponding to the study's design type. Fifteen studies were assessed using the Quality Assessment of Observational Cohort and Cross-Sectional Studies tool, one was assessed using the Quality Assessment of Controlled Intervention Studies, and one study was assessed using the Quality Assessment of Case Series tool. The assessment of quality returned one 'good', seven 'fair' and nine 'poor' rated studies. See Appendix 9 for a detailed quality assessment of all included studies. The following section will summarise the quality and risks of bias across the criteria outlined by the NIH tools used in this review and synthesize the information according to *methodological considerations* and *study design and analyses*.

Methodological considerations

Research question specification and outcome pre-specification

A specific and explicitly defined research question is crucial for giving a scientific paper direction and describes the first quality criterion against which cross-sectional and cohort studies were assessed. All but one study (5) of poor quality clearly stated the research questions or objectives, and a minority also provided hypothesised outcomes. The only RCT included in this review (10), which was of fair quality overall, pre-registered the trial protocol on a publicly accessible database. Pre-specifying outcomes and pre-registering research decreases the threat to validity from selective reporting (Stewart et al., 2020) and reduces

bias-generating practices such as Hypothesising After the Results are Known (HARKing; Munafò, 2016).

Sample description

Regarding the criteria on how thoroughly the study population was described, the majority of the studies outlined the study population in detail and provided a plethora of participant variables to characterise the sample. One study (8) of poor quality reported especially limited participant demographic information. A common omission noted across the studies was the absence of reporting on the recruitment location or duration. All studies except two (15, 16), both of poor quality, recruited participants from the same or similar populations. Two same studies (15, 16) recruited nurses and social workers from hospitals and departments where incidents of terror were prevalent and in those where they were not. However, they did not report on the intrusive memory incidence among these two settings, significantly increasing reporting bias. It was not possible to determine, nor was it reported whether the participation rate of eligible persons was at least 50% in over half of the cross-sectional and cohort studies (eight out of fifteen). Identifying studies not meeting this quality criterion is important as it increases the risk of the study population not adequately representing the target population. For studies where this was omitted, the most commonly identified reason among the four poor quality studies was that inclusion/exclusion criteria were not reported (6, 7, 15, 16) or only a final participant number was reported, without the mention of how many participants were not eligible (e.g., 1). The quality criterion regarding statistical power for justifying the study sample size enables an assessment of whether the study had sufficient participants to detect an association if one existed. Eleven studies did not report a power analysis or variance and effect estimates, nor did they justify their sample size (1, 2, 3, 6, 7, 8, 12, 13, 15, 16, 17). These studies were all of either poor or fair overall quality.

Sampling

The majority of the studies utilised opportunity sampling (2, 3, 4, 8, 10, 13, 14, 15, 16), restricting the generalisability of findings. A small portion of studies utilised solely volunteer sampling, as in a fair quality study (11), or a combination of both, as in one poor and one fair quality study (7, 12). Self-selection into research increases the bias for people who recognise experiencing intrusive memories as significantly problematic, limiting the external validity of findings. Only one study (1) of poor quality employed a probability sampling method, specifically stratified cluster sampling, thus having a lower volunteer bias (i.e., those individuals who volunteer may be characteristically distinct to those who choose not to). Four studies (5, 6, 9, 17), of which the majority were of poor quality (5, 6, 17) did not report on the sampling methodology used, therefore further increasing the risk of bias, for example, being unable to discern whether individuals from difficult-to-reach groups have been omitted or whether pre-set sampling rules have been deviated from.

Measures of intrusive memories and functioning

The criteria regarding exposure and outcome measures allows for exploration of whether studies used accurate, valid, and reliable measures. There was heterogeneity in the way that intrusive memories were defined and measured by the studies included in this review. Four (1, 6, 12, 17) of seventeen studies, of which three (1, 6, 17) were of poor quality, included 'thoughts' in the definition of intrusive memories, two studies(6, 13) of poor quality used PTSD outcome measure subscales as definitions and four studies (4, 8, 11, 13) of poor (8, 13) and fair (4, 11) quality did not clearly specify the definition used when explaining the concept to participants. Eight studies used self-rated idiosyncratic measures to assess intrusive memories. Of these, five utilised a Likert-type rating scale (2, 7, 11, 15, 16) and three recorded the number of intrusive memories either in a pen-and-paper diary format (9, 14; of fair and good quality, respectively) or in an electronic diary/smartphone app (12; of

fairy quality). Retrospective self-report brings into question the validity and reliability of the responses, possibly increasing recall bias. For example, one study (8) of poor quality asked people to rate how much intrusive memories affected their functioning in the first week after the traumatic event. The retrospective nature of this assessment does not control for time since the index trauma which may significantly affect recall. Further, there was variability in the characteristics of intrusive memories that was assessed for, which makes comparability between studies difficult. The majority of studies assessed intrusive memory frequency (n = 6) and only two studies, both of fairy quality, looked at intrusive memory characteristics (i.e., intensity, intrusiveness, vividness, nowness of intrusive memories; 2, 11). Five studies measured intrusive memories as part of specific items on a validated trauma/PTSD measure (1, 3, 4, 6, 13). Intrusive memories were also assessed using semi-structured interview schedules in two studies (5, 17) of poor quality.

Functioning outcomes were most commonly assessed using self-rated idiosyncratic measures (n = 7), of which two were a binary assessment (2, 13) and five were using a Likert-type rating scale (7, 8, 11, 12, 17). There were four studies (7, 8, 9, 10) which used Likert-type rating scales to assess the impact of intrusive memories on functioning outcomes directly, instead of using a separate measure for intrusive memories and another for the functioning outcome, e.g., in one study (7) of poor quality: "how much did your intrusive memories disrupt your concentration?" rated from 0 ('not at all disruptive') to 10 ('extremely disruptive'). Where self-reported data is used, there is a risk of a response-shift bias (Howard, 1980). This phenomenon occurs when a participants' frame of reference changes over timepoints of measurement (Rosenman et al., 2011). This is especially relevant to a study evaluating an intervention (10), which was of fair quality, where the treatment effect confounded with bias recalibration. Moreover, an intervention may influence participants' awareness of intrusive memories which, in turn, may change the estimation of the associated

functioning (Sprangers and Hoogstraten, 1989). A significant portion of the included studies assessed functioning using items or subscales of validated measures (1, 3, 4, 6, 13, 14, 15, 16). Semi-structured interview schedules were used to assess functioning outcomes in two studies (5, 17).

Study design and analyses

When evaluating the type of design used by the studies, it was important to consider the quality criterion exploring whether there was enough time for an exposure to have an effect on outcome. Ten of the studies were cross-sectional in design and assessed both exposure and outcomes at a single time point. Conclusions regarding causality of trauma-related intrusive memories and functioning cannot therefore be drawn.

The included studies predominantly utilised descriptive (n = 5) or simple bivariate correlational (n = 10) analyses given their single timepoint measurement. Studies employing simple bivariate correlational analyses represent weaker designs as they do not allow for the control of potential confounders. Two studies (15, 16) of poor quality employed both linear and hierarchical regression analyses, but it is important to note that they were both cross-sectional studies, thus maintaining ambiguity about the causal interpretation. This is in contrast to an RCT (10) of fair quality where the randomisation process helped to control for possible confounders. Two studies (4, 6), the former of fair quality and the latter of poor quality, employed a relatively novel network modelling approach to understanding a disorder by conceptualising it as collections of symptoms (i.e., systems) which are causally connected. While network modelling carries the advantage of acknowledging that symptoms of a disorder do not share one causal underpinning or that disorders are mere collections of arbitrary set of symptoms, it also presents limitations which impact on the interpretative power of the findings (Borsboom & Cramer, 2013). For example, inferences drawn from the studies need to be interpreted cautiously as network analyses do not constitute causal

associations. Specifically, one study (4) of fair quality may need a replication of their findings among a variety of samples as the confidence intervals of many of the edges between symptoms are large. Of the four studies which conducted a follow-up, two (3, 4) which were of fair quality met the quality criteria of greater than 20% loss to follow-up.

Relationship between intrusive memories and functioning

The primary aim of this review was to present a synthesis of the evidence on the associations between trauma-related intrusive memories and functioning. The functioning constructs assessed by the seventeen studies included in this review were classified under two ICF categories: domain *b Body Functions* and domain *d Activities and Participation*. The only relevant subcategory of domain *b* assessed in the included studies was *b1 Mental Functions*. Under the ICF, *b1* comprises functions of the brain, including both global mental functions such as energy and drive functions, and specific mental functions such as sleep or attention functions (WHO, 2002). Except for the subcategory *d3 Communication*, all subcategories within the ICF domain *d Activities and Participation* were relevant to the included studies: *d1 Learning and Applying Knowledge* describing abilities such as acquiring skills; *d2 General Tasks and Demands* encompassing aspects of carrying out everyday tasks and handling stress; *d4 Mobility* , *d5 Self-care* including tasks such as washing oneself, dressing, eating or drinking, and looking after one's health and well-being; *d6 Domestic Life* describing domestic and everyday tasks such as household cleaning; *d7 Interpersonal Interactions and Relationships* pertaining to basic and complex interactions with others; and *d8 Major Life Areas* encompassing aspects of one's functioning within the realm of education, work, employment and economic life (WHO, 2002). It was possible to classify most constructs measured by the studies under one subcategory, e.g., concentration under subcategory *b1*. Some studies, however, measured a more general psychological construct,

whose parts could be classified within several ICF subcategories. For example, one study (3) measured well-being using the Positive Well-being Scale (WBQ; Bradley & Lewis, 1990), which assesses several aspects of life satisfaction, including self-identity, relationships and lifestyle, and can thus be classified within *d2, d5,* and *d7*. Classifications of studies according to functioning constructs and within ICF subcategories are summarised in Table 3.

Table 3. Classification of studies according to functioning construct and within the International Classification of Functioning, Disability and Health subcategories of domain *b Body Functions* and *d Activities and Participation*.

Functioning construct	ICF domain	Study ID, Authors (year)	Percentage of study quality ratings
Domain *b Body Functions*			
Auditory hallucinations	*b1*	1 Alsawy et al., (2015); 2 Brand et al., (2020)	50% Fair, 50% Poor
Concentration	*b1*	4 Bryant et al., (2017); 6 Fried et al., (2018); 7 Holmes et al., (2017); 9 Kanstrup et al., (2020); 10 Kanstrup et al., (2021)	50 % Fair, 50% Poor,
Disinterest in activities	*b1*	4 Bryant et al., (2017); 6 Fried et al., (2018)	50% Fair, 50% Poor
Emotional functioning (e.g., anger, sadness, joy)	*b1*	4 Bryant et al., (2017); 11 Kleim et al., (2013); 17 Speckens et al., (2007)	66% Fair, 33% Poor
Rumination	*b1*	5 Evans et al., (2007); 17 Speckens et al., (2007)	100% Poor
Sleep	*b1*	4 Bryant et al., (2017); 6 Fried et al., (2018); 9 Kanstrup et al., (2020); 14 Luik et al., (2019)	25% Good, 50% Fair, 25% Poor
Domain *d Activities and Participation*			
Ability to settle in a new country	*d8*	9 Kanstrup et al., (2020)	100% Fair
Activities of Daily Living (ADL)	*d4, d5*	13 Letzter-Pouw & Werner (2005)	100% Poor
Alcohol/medication intake	*d5*	11 Kleim et al., (2013)	100% Fair
Global functioning (social, occupational or other important areas of functioning)	*d6-d8*	8 Iyadurai et al., (2019), 9 Kanstrup et al., (2020)	50% Fair, 50% Poor

Instrumental Activities of Daily Living (IADL)	*d6, d8*	13 Letzter-Pouw & Werner (2005)	100% Poor
Skill learning	*d1*	9 Kanstrup et al., (2020)	100% Fair
Stress levels	*d2*	9 Kanstrup et al., (2020); 12 Kleindienst et al., (2017); 15 Ron & Shamai (2011); 16 Ron & Shamai (2014)	50% Fair, 50% Poor
Well-being	*d2, d5, d7*	3 Briddon et al., (2015)	100% Fair

Association between intrusive memories and *Mental Functions*

In terms of *Mental Functions,* the most common areas of functioning impairments associated with intrusive memories were concentration, sleep and emotional functioning.

Concentration

Three studies found a relationship between intrusive memories and concentration disruption. In a fair quality case series study, intrusive memories were reported by all participants to have less impact on concentration over time, evidenced by a decrease in the ratings of how much intrusive memories disrupted concentration and sleep from T1 to T5 (9). The initial ratings varied among the four participants at T1, with 50% reporting very high to extreme disruption to their concentration. One study (7) found that on a scale from 0 to 10 (extreme concentration difficulties) 27% of participants rated "5–7" and over 36% indicated "8–10" when asked how disruptive intrusive memories are for concentration. Two studies (7, 9) looked at the length of disruption to concentration resultant from experiencing intrusive memories. The first study (7) found similar results whereby more than two thirds of participants indicated that intrusions disrupted their concentration for longer than 5 minutes and almost a third reported their concentration being disrupted by a single intrusive memory for longer than 30 minutes. The second study (9) found that the length of time that intrusive memories disrupted concentration on average ranged from 5 to 60 minutes. The inclusion of two open-ended questions supported these findings by suggesting that intrusions impacted

concentration in social situations (e.g., with friends), daily tasks, work and studies, and sleep disturbances (9). In a network analysis study (4), which was of fair quality, intrusive memories were found to be centrally associated with other symptoms in the acute phase (1 to 21 days) after a traumatic event, including concentration. In the chronic phase, at 12 months, this pattern was less prominent but still significant. Similar findings were found in a study of poor quality, where intrusive memories were among the most central symptoms in relation to functioning outcomes of concentration disruption (6). In the RCT study included in the review (10), and rated as fair quality, intrusive memories were associated with little disruption to concentration. Individuals in the intervention condition rated their intrusive memories to be causing less concentration disruption compared to the control condition at T1 (one week). At T3 (3-month follow-up), a similar pattern was observed, whereby the intervention condition participants reported lower ratings of concentration disruption. The pattern was reversed at T4 (6-month follow-up), demonstrating very small to small effect sizes.

Sleep

Four studies, of which 75% were rated as 'good' or 'fair' quality, identified significant associations between sleep disturbance and intrusive memories. The degree to which intrusive memories impacted on sleep (difficulties to fall asleep, maintain sleep or restless sleep) varied greatly among participants in one study (9). At T1, fifty percent of participants (n = 2) reported that intrusive memories disrupted their sleep 'very much'. Intrusive memories were reported by all participants to have less impact on sleep overtime (from T1 to T5). Similar findings were found by a good-quality rated study of 71 participants (14) where there were significant weak to moderate associations between the total number of intrusive memories for the first week post-trauma and problems in initiating and maintaining sleep, and dreams of the traumatic event at one week and maintaining sleep at one month.

Emotional functioning

Four studies found significant associations between intrusive memories and emotional functioning. Three studies measured anger (4, 11, 17) and one study (17) also assessed sadness and anxiety. There was only one study (11) among the emotional functions subcategory that compared the nowness and vividness of intrusive memories instead of the frequency. Significant positive associations were found between nowness and fear. Non-significant positive associations were found between vividness and fear, vividness and anger, and nowness and anger. One study (17) compared the emotional functions at the time of the trauma with emotional functions associated with experiencing intrusive memories following trauma. Anger and sadness were more prominent when experiencing an intrusive memory as compared to at the time of the trauma. This difference was statistically significant both for anger and for sadness. Anxiety on the other hand, was rated as stronger at the time of the trauma than when having an intrusive memory of the event, and this was also statistically significant.

Auditory hallucinations

One (2) of two studies (1, 2) found intrusive memories to be significantly associated with auditory hallucinations. A poor-quality rated study (1) found that intrusive memories were not significantly associated with auditory hallucinations. Conversely, a fair-quality rated study (2) utilising ecological momentary assessment found that intrusive memories which occurred within the preceding hour, were associated with auditory hallucinations with statistical significance. Indeed, an increase of one point on the trauma memory intrusions scale within the preceding hour increased the likelihood of a subsequent auditory hallucination by 43% on average. A strength of this study was that the latter finding controlled for proximal avoidance, hyperarousal and auditory hallucinations at a previous time point. There appeared to be a proximal relationship between intrusions and auditory

hallucinations whereby intrusions which occurred in the previous time period (60-120 min prior) did not significantly predict auditory hallucinations.

Disinterest in activities

Disinterest in activities was found to be associated with intrusive memories by two network analysis studies (4, 6), the former of good quality and the latter of poor quality.

Rumination

Studies assessing the relationship between intrusive memories and rumination were of poor quality (5, 17). Both studies reported that for the majority of their participants (90% and 73%, respectively), intrusive memories triggered rumination about the traumatic event. One study (5) additionally demonstrated that intrusive memories and rumination were moderately correlated.

Association between intrusive memories and *Activities and Participation*

In terms of *Activities and Participation*, intrusive memories of trauma were found to be most commonly associated with levels of stress. However, significant association between intrusive memories and functioning impairments in this ICF domain were found in all assessed functioning constructs in the included studies, apart from well-being.

Stress levels

Four studies looked at the relationship between levels of stress (subcategory *d2*) and intrusive memories (9, 12, 15, 16). High levels of stress were found to be related to intrusive memories in all four studies. In one study (12), the periods of measurement that were free of intrusive memories had significantly lower levels of associated aversive inner tension compared to those periods that had at least one intrusive memory. Similarly, 75% of participants in another study (9) found their stress levels to be 'very much affected' by intrusive memories. Importantly, intrusive memories were reported to have less impact on stress levels overtime, as shown by a decrease in the ratings from T1 to T5. Both studies

assessing level of stress were of fair quality. Two poor-quality rated studies supported these findings, whereby significant positive associations were found between intrusive memories and personal levels of stress. Intrusive memories added 21.2% and 19% to the explained variance of the personal level of stress, respectively (15, 16).

Global functioning

A study (8) which spanned several functioning domains (*d6-d8*), found that over 60% of individuals indicated that their intrusive memories of traumatic events had moderate to extreme impact on global everyday functioning, including social and occupational aspects as well as relationships with others, social life, work, parenting, schoolwork or housework. Responses from open-ended questions from one study with refugees (9) confer similar findings, whereby the impact of intrusive memories spans across several major life areas, including hindrances to planning future work, learning a new language, ability to settle in a new country, difficulties with aspects of parenting and a general hindrance in ability to engage with everyday life leading to a sense of disconnectedness.

Activities of daily living (ADLs) and Instrumental activities of daily living (IADLs)

A significant positive correlation was found between intrusive memories and the degree of help needed with performing ADLs, (i.e., eating, dressing, washing, using bathroom facilities, and mobility) within subcategories *d4* and *d5,* and IADLs, (i.e., shopping, house cleaning, daily activities and financial help) within subcategories *d6* and *d8*, in one study of poor quality (13). A study spanning three ICF subcategories, *d2*, *d5* and *d7*, found a non-significant negative association between the frequency of unpleasant intrusive memories and well-being in new mothers (3). Similarly, one study (11) found that those experiencing intrusive memories struggled with maintaining healthy choices, specifically that those with a diagnosis of PTSD reported more frequent alcohol and drug use (subcategory *d5*) in response to their intrusive memories compared to those who did not have a PTSD diagnosis.

Table 4. Study characteristics.

Study ID, Authors (year)	Country	Study aims relevant to this review	Study design	Definition of intrusive memories	Intrusive memory and functioning measures	Analyses	Effect size / statistic	Key findings related to this review	Quality rating
1 Alsawy et al., (2015)	UK	To examine the relationship between symptoms of PTSD and auditory hallucinations.	Observational - cross-sectional	Upsetting thoughts or memories about the event that come into one's mind against their will.	Trauma Screening Questionnaire (TSQ; Brewin et al. 2002); Psychosis Screening Questionnaire (PSQ; Bebbington & Nayani, 1995).	Regression analyses	OR = 0.74; 95% CI = 0.28–1.99	Intrusive memories were not significantly associated with auditory hallucinations.	Poor
2 Brand et al. (2020)	Australia	To examine moment-to-moment associations between posttraumatic stress symptoms and auditory hallucinations (AHs) using ecological momentary assessment.	Observational – ecological momentary assessment	Memories of the event(s) which came into the head when one does not want them to.	Intrusive memory intensity (i.e., how much they came to one's head when they didn't want them to) rated on a 7-point Likert scale from 0 ('not at all') to 7 ('a lot'). Binary assessment of auditory hallucinations: "I was hearing voices that other people cannot hear".	Correlation and regression analyses	Intrusion intensity and AH presence (binary): r = 0.46 Proximal predictor of AH: OR = 1.43; 95% CI = 1.15-1.77 Lagged predictor of AH: OR = 1.10; 95% CI = 0.97-1.26	Proximal intrusions (i.e., occurring in the hour preceding the EMA signal) were significantly associated with AHs. An increase of one point on the trauma memory intrusions scale in the hour preceding the signal increased the likelihood of an AH at the signal by 43% on average. Lagged intrusions (occurring 60-120 min prior) did not significantly predict AHs.	Fair
3 Briddon et al., (2015)	UK	To assess whether women's emotional	Observational – cohort	Memories of personal experiences (related to	Frequency of intrusive memories on two items of the Trauma Memory Questionnaire	Correlation analyses	r = -0.207	There was a non-significant negative association between unpleasant intrusive	Fair

		responses to involuntary memories are linked to subsequent post-partum emotional adjustment (i.e., well-being).		childbirth in this case) that come to mind spontaneously.	(TMQ Halligan et al., 2003); Positive well-being subscale of the well-being questionnaire (WBQ; Bradley & Lewis, 1990).			memory frequency and well-being.	
4 Bryant et al., (2017)	Australia	To examine the nature of the association between PTSD symptoms in the acute phase after trauma and the chronic phase.	Observational - prospective cohort	NS	Clinician-Administered PTSD Scale (CAPS; Blake et al., 1995). Functioning outcomes (i.e., disinterest in activities, sleep disturbance, anger and concentration deficits) were also assessed using the CAPS.	Network analysis	Effect size: Betweenness = -1.25; closeness = 1.36; strength = -0.11; Mean = 0.00.	Intrusive memories are centrally associated with concentration deficits, sleep disturbance and disinterest in activities in the acute phase (1 to 21 days) after a traumatic event. At 12 months (chronic phase), intrusions were less central in terms of betweenness.	Fair
5 Evans et al., (2007)	UK	To assesses intrusive memories and ruminations of posttraumatic stress disorder related to serious violent crimes perpetrated by young offenders.	Observational - cross-sectional	Memories that were part of what actually happened at the time, were recurrent, distressing, and involuntarily triggered.	Intrusion Interview (Michael et al., 2005); Rumination Interview (Michael et al., 2007; Speckens et al., 2007).	Correlation analyses	$\varphi = .50$	Intrusive memories and rumination were significantly moderately related. 90% of individuals reported that their intrusions triggered ruminations.	Poor

6 Fried et al., (2018)	Netherlands, Denmark	To assess the network structures of PTSD symptoms among traumatized patients receiving treatment for PTSD.	Observational - cross-sectional	This study used three measures to assess intrusive memories, all of which define intrusive memories as either, thoughts and images (PSS-SR); thoughts and memories (HTQ) and memories, thoughts and images (PCL-C).	Harvard Trauma Questionnaire (HTQ; Mollica et al., 1992); Posttraumatic Stress Symptom Scale Self-Report (PSS-SR; Foa et al., 1997); PTSD Checklist-civilian version (PCL-C; Weathers et al., 1993). Functioning outcomes (i.e., disinterest in activities, sleep problems, irritability and concentration problems) were also assessed using these measures.	Network analysis	NR	Intrusive memories were among the most central symptoms associated with concentration deficits, sleep disturbance and disinterest in activities.	Poor
7 Holmes et al., (2017)	Sweden	To assess concentration disruption and intrusive memory occurrence over a week.	Observational - retrospective cross-sectional as part of an interventional feasibility study	Visual pictures/ snapshot images or film clip, which can include other senses.	11-point Likert scale rating of intrusive memory frequency: "How many intrusive memories did you have in the last week?" 0 ('none') to 10 ('numerous / all the time'); ratings of concentration disruption using ordinal and Likert scales, e.g., "When you have an intrusive memory how long does it disrupt your concentration on average?" (<1 min, 1–5 min, 5–10 min, 10–30 min, 30– 60 min, >60 min); "Over the	Descriptive and correlation analyses	$r = 0.64$	Intrusive memories were significantly positively correlated with concentration difficulties. 68% indicated that intrusions disrupt their concentration for longer than 5 min and 32% reported disruption of longer than 30 min. 27% rated '5–7' when asked how disruptive intrusive memories are on their concentration on a Likert scale from 0 to 10 (10 being most	Poor

					last week, how much did your intrusive memories/flashbacks disrupt your concentration?" from 0 ('not at all disruptive') to 10 ('extremely disruptive').			disruptive) and over 36% indicated '8–10'.	
8 Iyadurai et al., (2019)	UK	To assess the subjective impact of intrusive memories on functioning and concentration in everyday life.	Observational - retrospective cross-sectional	NS	5-point Likert scale rating of intrusive memory impact on functioning: "How much did your intrusive memories in the first week after the traumatic event affect your functioning (social, occupational, or other important areas e.g., relationships with other people, social life, work, parenting, schoolwork, housework, volunteer work etc.)?" from 'no adverse impact' to 'extreme impact'.	Descriptive analyses	NA	Over 60% indicated that intrusive memories had 'moderate' to 'extreme' impact on their everyday functioning.	Poor
9 Kanstrup et al., (2020)	Sweden	To assess the impact of a behavioural intervention (including an assessment of intrusive memories) on functioning.	Experimental - case series	Visual trauma images.	Intrusive memories recorded in a daily pen-and-paper diary; 11-point Likert scale used to assess concentration difficulties, sleep disturbance stress levels due to intrusive memories from 0 ('not at all') to 10 ('very');	Descriptive analyses	NA	Intrusive memories were reported to impact negatively on levels of stress, concentration and sleep. The impact and the frequency of intrusive memories was perceived to reduce over time	Fair

					length of time intrusive memories disrupted concentration on a 6-point Likert scale (1 = <1min, 2 = up to 1–5min, 3 =5–10min, 4 = 10–30min, 5 = 30–60 min and 6 = > 60 min); two-open ended questions about how intrusive memories interfere with concentration and ability to settle in Sweden and learn new skills, e.g., new language.			(T1 to T5) following the intervention being implemented.	
10 Kanstrup et al., (2021)	Sweden	To assess functional impairment resultant from the experience of intrusive memories and to identify the extent to which reductions in intrusive memories were associated with functional improvements (e.g., sleep, concentration).	Experimental - RCT	Visual memories and not verbal thoughts.	11-point Likert scale assessing the degree of concentration disruption due to intrusive memories from 1 ('not at all') to 9 ('very').	Descriptive analyses	Concentration disruption at 1 week: *d* = 0.80, 95% CI = 0.05, 1.55; 1 month: *d* = 0.43, 95% CI = -0.29, 1.15; 3 months: *d* = 0.09, 95% CI = -0.64, 0.82; 6 months: *d* = -0.25, 95% CI = -1.05; 0.55.	Intrusive memories were perceived to cause little disruption to concentration (mean ratings between 1.27 and 2.39 on Likert scale). At 1 week and 1 month (T1 & T2): those in the intervention condition rated their intrusions as causing less concentration disruption compared to the control condition. Those in the intervention	Fair

								condition reported lower rating at 3 months (T3) and a reverse pattern was observed at 6-months (T4).	
11 Kleim et al., (2013)	NR	To examine the characteristics of intrusive memories (e.g., intrusiveness, vividness, nowness) in trauma survivors' everyday lives. Further, the study aimed to assess within-person associations between intrusion characteristics, emotional responses (e.g., anger), and cognitive-behavioural responses (e.g., alcohol/medication intake).	Observational - ecological momentary assessment	NS	7-day electronic diary to record intrusive memory characteristics (intrusiveness, vividness and nowness) on a visual analogue scale from 0 to 100, emotional response (anger, shame, guilt, fear, helplessness) on a scale from 0 to 100, and cognitive-behavioural responses (i.e., alcohol/medication intake).	Correlation analyses	Vividness and fear: r = 0.45 PTSD-diagnosis group and alcohol/drug use: d = 0.60.	A significant positive association was found between intrusive memory nowness and fear. Non-significant positive associations were found between vividness and fear, vividness and anger, and nowness and anger. Individuals with PTSD reported more alcohol and drug use in response to their intrusive memories.	Fair
12 Kleindienst et al., (2017)	Germany	To assess the frequency of intrusive	Observational - cross-sectional as	Defined according to the DSM-IV and	The number of episodes of trauma-related intrusive	Correlation analyses	TBS-block: Wilcoxon S = 483.	Intrusive memories were found to be associated with a	Fair

		memories in individuals with PTSD related to interpersonal violence.	part of an experimental study	included sensory memories and trauma-related thoughts.	memories and their duration was recorded using event-based and time-based sampling methods on a professional smartphone app. Current levels of aversive inner tension were assessed on a visual analogue scale from 0 to 100.		EBS-block: Wilcoxon S = 184.5.	high level of aversive inner tension. Mean levels of aversive inner tension differed significantly between the 2 hour-periods which were free of intrusive memories v. 2 hour-periods which included at least one intrusive memory in the TBS-block. The mean aversive inner tension during the EBS-phase was found to be higher and differing significantly from the TBS-block which had at least one intrusive memory.	
13 Letzter-Pouw & Werner (2005)	NR	To assess the correlates of intrusive memories.	Observational - cross-sectional	Defined according to three Intrusion-subscale items of the IES (but NS which three).	Intrusive memories were measured by three items from the Impact of Event Scale (IES; Horowitz et al., 1979). Activities of Daily Living (ADL) were assessed using the Katz scale (Katz et al., 1970), i.e., the extent to which individuals need support with five	Correlation analyses	ADL: r = 0.22 IADL: r = 0.30	A significant positive correlation was found between intrusive memories and degree of help needed with performing ADLs, and IADLs.	Poor

					ADLs: eating, dressing, washing, using bathroom facilities, mobility. Each item is rated on a 5-point Likert scale from 1 ('independent') to 5 ('needs help all the time'). Instrumental Activities of Daily Living (IADL) were assessed by exploring how much help is needed with the performance of four activities: shopping, house cleaning, daily activities and financial help. Binary rating of 1 = no ('does not need help') or 2 = yes ('does need help').				
14 Luik et al., (2019)	UK	To assess the association between the number of intrusive memories over the first week after trauma and self-reported sleep disturbance (trouble initiating sleep, trouble maintaining sleep and	Observational - longitudinal	Image-based memories.	Intrusive memories were recorded in a daily pen-and-paper diary. Sleep was assessed using the IES-R (Creamer et al., 2003) item 15 ('I had trouble falling asleep'), item 2 ('I had trouble staying asleep') and item 20 ('I had dreams about it').	Correlation analyses	At one week: initiating sleep: r = .34; maintaining sleep: r = .37; dreams of the traumatic event: r = .26. At one month: maintaining sleep: r = .30.	There were weak to moderate associations between the total number of intrusive memories for the first week post-trauma and problems initiating and maintaining sleep, and dreams of the traumatic event at one week and maintaining sleep at one month.	Good

		dreams about the traumatic event) at one week and one-month post-trauma.							
15 Ron & Shamai (2011)	Israel	To assess the contribution of intrusive memories to the personal distress level (level of stress) of social workers in Israel.	Observational - cross-sectional	Memories, images, or voices of the traumatic event running through one's mind during the day or whilst asleep (as dreams).	5-point Likert scale measuring intrusive memory frequency, ranging from 1 ('never') to 5 ('very frequently'). Level of personal stress was measured using the Hebrew version (Gilbar & Ben-Zur, 2002) of the Brief Symptom Inventory (BSI; Derogatis & Spencer, 1982). Three subscales were used: anxiety, depression and somatisation, where items are rated on a 5-point Likert scale from 0 ('not at all') to 4 ('very much').	Correlation and regression analyses	$r = 0.21$	There was a significant positive association between intrusive memories and personal level of stress. Intrusive memories added approximately 21.2% to the explained variance of the personal level of stress; when both intrusive memories and burnout were added, intrusive memories explained approximately 18.8% of the variance.	Poor
16 Ron & Shamai (2014)	Israel	To assess the contribution of intrusive memories to the level of personal distress of hospital nurses in Israel.	Observational - cross-sectional	Memories, visions, or voices of the traumatic event running through one's mind during the day or whilst asleep (as dreams).	5-point Likert scale measuring intrusive memory frequency, ranging from 1 ('never') to 5 ('very frequently'). Level of personal stress was measured using the Hebrew version (Gilbar & Ben-Zur, 2002) of the Brief	Correlation and regression analyses	$r = 0.42$	There was a significant positive association between intrusive memories and personal level of stress. Intrusive memories added approximately 19% to the explained variance of the personal level of	Poor

					Symptom Inventory (BSI; Derogatis & Spencer, 1982). Three subscales were used: anxiety, depression and somatisation, where items are rated on a 5-point Likert scale from 0 ('not at all') to 4 ('very much').			stress; when both intrusive memories and burnout were added, intrusive memories explained approximately 12% of the variance.	
17 Speckens et al., (2007)	UK	To conduct a direct comparison between intrusive memories and rumination using phenomenological characteristics and accompanying emotions.	Observational - cross-sectional	Intrusive recollections as thoughts, feelings or sensory experiences.	Intrusion and Rumination Interview (Ehlers et al., 2002; Hackmann et al., 2004; Michael et al., 2005) to ascertain presence of intrusive memories and rumination. Strength of emotional functioning (e.g., anxiety, anger, sadness) was rated on a 5-point Likert scale from 0 ('not at all') to 4 ('extremely').	Inferential statistics and descriptive analyses	Anger: t = -2.25; sadness: t = -1.92. Anxiety: t = 2.34.	Anger and sadness reactions were rated as significantly stronger when felt after experiencing intrusive memories of the trauma compared to at the time of the trauma. Anxiety was rated as significantly stronger at the time of the trauma than when having an intrusive memory. 73% reported that intrusive memories often triggered rumination about the traumatic event.	Poor

Note: ADL = activities of daily living, AH = auditory hallucination, CI = confidence interval, EBS = event-based sampling, EMA = ecological momentary assessment, IADL = instrumental activities of daily living, NA = not applicable, NR = not reported, NS = not specified, OR = odds ratio, RCT = randomised controlled trial, TBS = time-based sampling.

Discussion

The aim of this systematic review was to consider the relationship between intrusive memories of traumatic events and functioning, taking into account the quality of the research available. To our knowledge, this is the first review focusing on the association between functioning, as described by the WHO, and trauma-related intrusive memories that are a) reported and analysed in non-clinical, sub-threshold PTSD or PTSD diagnosed populations, and b) in isolation to other symptoms of PTSD i.e., not as part of the PTSD re-experiencing cluster. Thus, the inclusion criteria were broad, considering peer-reviewed studies which reported on intrusive trauma memories, and functioning outcomes relevant under the ICF (WHO, 2002). The functioning outcomes relevant to the seventeen studies included in this review spanned two of four domains in the ICF, domain *b Body Functions*, and domain *d Activities and Participation*.

Summary of findings

Fifteen out of the seventeen studies found supporting evidence for an association between intrusive memories and functional impairment. A strong pool of evidence exists for relationships between intrusive memories and sleep disturbance (which comes under ICF subcategory *b1 Mental functions*), given the number and quality of the studies reporting on these findings (n = 4). Specifically, difficulties with initiating or maintaining sleep, or restless sleep, were found to be associated with the experience of intrusive memories. Only one of seventeen studies was of good quality and thus provides the most robust evidence for the significant relationship between intrusive memories and impairments in sleep. Another key finding in four studies was a relationship between intrusive memories and disrupted concentration (subcategory *b1*), with the majority (n = 3) being in the more extreme levels of

impairment. A relatively large number of studies (*n* = 4) found a relationship between intrusive memories and emotional functioning (subcategory *b1*), specifically anger, fear, sadness and anxiety. Despite significant associations being found between rumination (subcategory *b1*) and intrusive memories, these findings need to be considered carefully, given that the studies (*n* = 2) were all of poor quality and possessed severe methodological weaknesses. The most commonly found impairment in functioning within domain *d Activities and Participation* associated with intrusive memories were levels of stress (subcategory *d2*) experienced by participants (*n* = 4). There were two studies assessing global impairment spanning social, occupational, home life and interpersonal aspects of one's functioning (subcategories *d6*-*d8*) and they found significant associations with intrusive memories. Caution is needed with these studies due to poor quality ratings and the over-reliance on small sample sizes (*n* = 4). Furthermore, relationships between intrusive memories and the degree of help needed when performing ADLs and IADLs (subcategories *d4* and *d5*) were present as evidenced by one study. Finally, one study of fair quality found intrusive memories to be associated with frequent alcohol and drug use (subcategory *d5*). Two studies found non-significant associations between intrusive memories of trauma and well-being (subcategories *d2*, *d5* and *d*; fair quality study), and intrusive memories and auditory hallucinations (subcategory *b1;* poor quality study). The latter is inconsistent with a fair-quality study which found significant associations between intrusive memories and auditory hallucinations. Caution is needed when interpreting results from studies with poor methodological quality, especially given the many potential confounding variables.

Theoretical implications

This systematic review emphasises the importance of functioning impairments in individuals who experience trauma-related intrusive memories, whilst recognising the limitations of the conclusions. The findings are concordant with those of a recent meta-

analysis by Jellestad and colleagues (2021) which found that individuals with PTSD compared to healthy subjects showed significant (*ps* < 0.001) impairments across all subcategories of domain *d Activities and Participation* of the ICF with large to very large effect sizes (*ds* > 1). Specifically, the re-experiencing cluster of PTSD was found to be significantly associated with parent, child, and family functioning problems, marital/partner relationship problems as well as intimacy problems with small effect sizes (Birkley et al., 2016). However, whilst the findings from both of these meta-analyses support the findings of this review given that intrusive memories are a core symptom of PTSD (Bryant et al., 2017), neither give an indication as to which symptom or groups of symptoms impact functioning in what capacity.

The association between intrusive memories and functioning impairments could be hypothesised in multiple ways. Firstly, the cognitive model of PTSD postulates that unbidden intrusive memories are accompanied by increased arousal. This includes, for example, raised heartrate or fast and shallow breathing resulting in a hyperarousal of the central nervous system (Ehlers & Steil, 2009). A state of hyperarousal can impact on several aspects of functioning, such as deficits in attentional processes (Vasterling et al., 1998), precluding someone from sleeping (Luik et al., 2019), chronic levels of stress (Kendall-Tackett, 2000), or unhelpful ways of coping, for example, alcohol use (Duranceau et al., 2014). The cognitive model also proposes that intrusive memories are sensory-perceptual memories which come to the mind unbidden and 'hijack' selective attention (Clark & Mackay, 2015; Ehlers &. Clark, 2000). Individuals with PTSD have been found to have increased priming for perceptual and trauma-related stimuli (Michael et al., 2005), where the mechanism appears to be an inability to switch their attention away from trauma-related stimuli (Pineles et al., 2007). In turn, interruptions in selective attention make maintaining effortful awareness, i.e., concentration, difficult (Moran, 2012). By this mechanism, intrusive memories involuntarily intruding into

the mind may disrupt concentration. Sleep impairments associated with intrusive memories could also be understood in the context of the relationship between intrusive memories and nightmares, which both comprise the same DSM-5 PTSD cluster (APA, 2013). Intrusions and nightmares were two symptoms found to be highly interconnected in a network analysis study (Birkeland & Heir, 2017). Secondly, the dual representation theory of PTSD proposes that secondary emotions such as anger are often more strongly present in post-trauma sequalae than during the time of the trauma (Brewin & Dalgleish, 1996). Therefore, it is unsurprising that aspects of emotional functioning are closely linked to intrusive memories. This evaluation is congruent with the findings of four studies in this review and is further supported by the information-processing model which posits that following traumatic events, two internal and opposing processes arise, a) intrusive experiences which trigger distress b) emotional denial, including emotional numbing (Horowitz, 1986). Is it hypothesised that this process allows PTSD patients to reduce the distressing feelings associated with the intrusive memories (Litz & Grey, 2002). Finally, whilst this review identified non-significant associations between negative intrusive memories and well-being in new mothers, positive experiences of childbirth were related to less avoidance of negative intrusive memories which is postulated to facilitate the processing of these memories (Dale-Hewitt et al., 2012).

Clinical implications

Crucially, this review found that intrusive trauma memories are associated with functioning impairments *even if* they occur outside of a diagnosed mental health condition such as PTSD or ASD. This is supported by evidence of individuals with sub-threshold PTSD symptoms having comparable levels of impairment in social and work functioning when compared to patients with a full PTSD diagnosis (Zlotnick et al., 2002). Given that intrusive memories are distressing in their own right (Ehlers & Steil, 1995), are placed at the centre of PTSD symptomatology by cognitive models of PTSD (Brewin, 2014; Ehlers & Clark, 2000)

and, as suggested by this review, are associated with functional impairment, the main clinical implication and the critical next step is focusing on developing interventions that are driven by targeting this single symptom. This would be important even if someone does not have a full diagnosis of PTSD or ASD. Further, clinicians might find it useful to focus on the symptom-specific burden by expanding assessments to include functional impairments ahead of planning therapeutic treatment which extends beyond approaches that focus on relieving clinical symptoms and the associated distress per se. Given that the impairments associated with intrusive memories span a multitude of functioning domains, a range of interview, self-report, and standardised measures would provide a robust picture of one's abilities.

Strengths and limitations

This review has several limitations. Firstly, over half of the studies included in this review were of poor quality. Overreliance on cross-sectional design means it is not possible to adequately account for important covariates, such as a) time since the index traumatic event b) time since the onset of intrusive memories, or c) other mental health symptoms. These covariates may have important implications for the severity and type of functional impairment. Secondly, the heterogeneity of the studies in terms of methodology, exposure and outcome measurement, trauma type, and sample size, limits the ability of this review to synthesise the data and precluded a meta-analysis being carried out. Despite this, some of the heterogeneity was partially controlled by grouping the findings within the ICF domains. Further, grouping the studies within ICF domains allowed for results from a broad range of functioning measures to be combined in a narrative synthesis. Thirdly, there were only a few ICF subcategories which featured among the studies in this review, which limits the representativeness of the information synthesised. This variability impedes meaningful replication, further limiting the ability to build a strong evidence base pertaining to the relationship between intrusive memories and functioning outcomes. The findings of this

review highlight the need for future methodologically robust and conceptually sound replicable studies to enrich the current evidence base investigating links between intrusive trauma memories and functioning outcomes. Fourthly, studies published in other languages other than English were excluded, limiting the findings in the current review. The study samples spanned seven countries which allowed for a degree of socio-cultural generalisability of findings. Finally, studies which were not published in peer-reviewed journals were also excluded, possibly introducing publication bias. This was done to ensure the highest quality methodology.

Almost all of the studies considered the relationship between intrusions and functioning as a secondary or tertiary outcome. Very few studies set out to investigate the association between intrusions and functioning as a primary aim of their empirical research. This meant that full texts were reviewed to identify if further analyses between intrusions and possible functioning outcomes were carried out, increasing the risk of studies being missed.

One of the strengths of the quality assessment tool used in this review resided in there being a specific tool for the type of study being reviewed. Thus, the items that the study quality were assessed against were tailored specifically to the design of the study. However, given the breadth of the inclusion criteria, this review included a range of study designs, both observational and experimental. This has meant that despite the overall quality rating being likely more accurate due to the idiosyncratic nature of the tool tailored to the design, it does not allow for direct comparison of individual quality criteria across studies of different designs.

Future research recommendations

Most of the studies included in this review were observational or cross-sectional, confining the research to the strength of the *association* between intrusive memories and functioning outcomes. Future studies are needed to examine the causal impact of intrusive

memories on functioning and the temporal relationship between these two variables. Prospective and longitudinal designs evaluating intrusive memories assessed at T1 as an independent predictor of functioning at subsequent timepoints could be helpful. Similarly, studies where the design does not solely rely on subjective retrospective recall would further boost the findings in this field and help to reduce recall bias. Crucially, idiosyncratic measures of functioning that allow us to examine what is important to that person are needed. That way it can be assessed whether the interventions tackling intrusive memories are making a difference to what matters to the individual. Further research utilising a combination of subjective and validated measures would strengthen the conclusions drawn from the findings. A surprising finding, and an important consideration, is the heterogeneity in which intrusive memories are conceptualised and defined in the studies. Approximately 25% of the included studies encompassed both intrusive thoughts and visual images within the definition, making it impossible to distinguish the impact each phenomenon has on functioning. This is especially important, given that intrusive thoughts are regarded as a separate construct to intrusive images (Hagenaars et al., 2010). Future research would benefit from clearer, more precise and conceptually robust definitions of this construct. Finally, most studies considered intrusive memory frequency as an outcome and only a few measured intrusive memory characteristics associated with functioning. The field would benefit from future studies investigating the properties of intrusive memories which are predominantly associated with poor functioning outcomes. It remains to be clarified whether the number of intrusive memories, or other characteristics such as nowness or distress, are related to functional impairments.

Conclusion

This systematic review found that intrusive memories of trauma are associated with functional impairments across a range of ICF domains including sleep, concentration, emotional functions, levels of stress, rumination, and activities of daily living. The important next step is to investigate predictive associations between intrusive memories and a) the functioning outcomes for which associations with intrusive memories have already been identified by this review, and b) functioning outcomes not evidenced in this review but categorised under ICF domains. Future studies would benefit from agreeing on the conceptual definition of intrusive memories, the key characteristics of intrusive memories that are most impactful on functioning (e.g., frequency or vividness), use of validated and idiosyncratic measures, and robust longitudinal designs. The link between intrusive memories and functional impairment implicates intrusive memories as an important treatment target which ought to be researched further.

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Paper B

Reducing Intrusive Memories of Work-Related Traumatic Events in Frontline Healthcare Staff during the COVID-19 Pandemic: A Case Series Evaluating the Effectiveness of a Brief Cognitive Task Intervention

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Reducing Intrusive Memories of Work-Related Traumatic Events in Frontline Healthcare Staff during the COVID-19 Pandemic:

A Case Series Evaluating the Effectiveness of a Brief Cognitive Task Intervention

Abstract

Background: Frontline healthcare staff are frequently exposed to traumatic events and levels of exposure have been heightened by the COVID-19 pandemic. Many healthcare workers report intrusive memories of these events, which can elicit distress, affect functioning, and be associated with longer-term PTSD symptoms. **Objectives:** The current case series aimed to (a) investigate the effectiveness of a brief cognitive task intervention on the number of intrusive memories, general functioning (e.g., concentration, sleep), and symptoms of posttraumatic stress, anxiety and depression, and (b) examine the feasibility and acceptability of the intervention for healthcare staff. **Method:** Fourteen clinical National Health Service (NHS) staff from emergency and intensive care departments, and the ambulance service received the intervention. The intervention was evaluated using an AB single-case experimental design methodology, where the baseline ('A') was the monitoring-only phase, and the post-intervention ('B') period was the time after the intervention was first administered. **Results:** Results showed a statistically significant reduction in the number of intrusive memories from baseline to post-intervention in an aggregated omnibus analysis with a small effect size (Tau-U = -0.38, p = <.001). There was also a decrease (60%) in the mean number of intrusive memories per day from baseline (M = 1.37) to post-intervention (M = 0.59). Participants reported improved functioning. Posttraumatic stress, anxiety and depression symptoms all significantly reduced from baseline to post-intervention. The intervention was feasible to deliver and rated as acceptable by staff. **Conclusions:** These findings suggest that this brief cognitive intervention could offer a potentially accessible and scalable approach driven by mental health science to mitigate the impact of work-related

traumatic events in healthcare staff, both during the ongoing pandemic and beyond. Randomised controlled trials will be an important next step.

Word count: 282 words

Introduction

Frontline healthcare staff, such as emergency and intensive care department staff and paramedics, are frequently faced with highly stressful, emotive, and traumatic clinical events in the course of their work. A traumatic event is defined as "exposure to actual or threatened death, serious injury, or sexual violence", through directly experiencing the traumatic event, indirectly witnessing the event as it occurred to somebody else, learning of the event occurring to a loved one, or experiencing aversive details of the traumatic event in a repeated or extreme way (American Psychiatric Association [APA], 2013, p. 271). For healthcare staff, examples of such events include witnessing the death or extreme suffering of patients, performing cardiopulmonary resuscitation (CPR) or treating patients with open wounds (Mealer et al., 2007). There is evidence that healthcare staff experience intrusive memories of work-related traumatic events. The rate was as high as 65% in a sample of emergency nurses (Kleim et al., 2015).

Intrusive memories are sensory and perceptual in nature, come to mind involuntarily, and can elicit a range of negative emotions associated with the trauma (Grey & Holmes, 2008). They typically occur in the form of visual images, but can also include smells, sounds, tastes, and physiological sensations associated with the trauma (Ehlers et al., 2005). For example, a healthcare worker might see in their mind's eye the image of a patient they treated with severe burn injuries, or the faces of the distraught parents of a young child when resuscitation was stopped (Kleim et al., 2015). Not only are intrusive memories emotionally distressing (Ehlers & Steil, 1995), they can also disrupt concentration (Holmes et al., 2017)

and interfere with daily functioning (Iyadurai et al., 2019). They therefore represent a treatment target in their own right.

Moreover, intrusive memories are a core symptom of post-traumatic stress disorder (PTSD) and acute stress disorder (ASD), defined within the DSM-5 as "recurrent, involuntary, and intrusive distressing memories of the traumatic event(s)" (APA, 2013, p. 271; PTSD criterion B1). They form part of the re-experiencing symptom cluster of PTSD, alongside recurrent distressing dreams, dissociative flashbacks and physiological responses to cues (APA, 2013). The findings of a longitudinal study following the 2011 Oslo bombing suggest that memories of the traumatic incident and the following intrusions seemed to drive posttraumatic stress symptomatology (Solberg et al., 2016). Further, there is evidence that intrusive memories are centrally associated with other PTSD symptoms (Bryant et al., 2017). Such findings have prompted the suggestion that targeting and reducing intrusive memories might even in turn reduce other PTSD symptoms "…in a kind of therapeutic cascade" (McNally, 2012, p. 225).

Even prior to the COVID-19 pandemic, rates of PTSD in NHS healthcare staff were high. In one study, twenty-one percent of 56 ambulance service workers met criteria for PTSD (Clohessy & Ehlers, 1999). The same prevalence (21%) was found among 173 hospital-based nurses (Czaja et al., 2012). Further, in a study of 51 emergency department staff 20% met PTSD symptom criteria (Laposa & Alden, 2003). Rates of PTSD in these populations have escalated during the pandemic. A recent systematic review and meta-analysis found rates of PTSD at 21.5% (95% CI, 10.5%-34.9%) among healthcare workers (*n* = 97, 333) across 21 countries (Li et al., 2021). Intensive care unit (ICU) staff appear to be especially vulnerable. A recent survey of ICU staff indicated that 40% had probable PTSD (Greenberg et al., 2021). Notably, PTSD symptoms have an adverse impact on work functioning in healthcare staff; they can interfere with job performance, lead to burnout and

make staff consider changing their jobs (Laposa & Alden, 2003). Kok and colleagues (2021) reported that burnout symptoms in ICU professionals rose from 23% prior to COVID-2019 to 36.1% post-peak of the pandemic. The British Psychological Society (BPS) has highlighted the importance of attending to the psychological needs of healthcare staff as a central focus following the pandemic. The development and evaluation of effective treatments targeting intrusive memories to protect the mental wellbeing of healthcare staff is therefore an urgent priority (Holmes et al., 2020; The Lancet Psychiatry, 2021).

Existing interventions as recommended by the National Institute for Health and Care Excellence (NICE, 2018), such as trauma-focused cognitive behavioural therapy ([CBT], e.g., Rothbaum et al., 2012) and Eye Movement Desensitization and Reprocessing therapy ([EMDR] e.g., van der Kolk et al., 2007) are time-consuming and can be difficult for healthcare staff to access as they require attending fixed sessions with a therapist. Furthermore, mental health stigma is commonplace within healthcare (Knaak et al., 2017); and talking therapies can also be associated with stigma (Anderson & Brownlie, 2011). Stigma permeating the healthcare workplace has contributed to a diminished willingness to identify with and seek help for mental health disorders among staff (Modgill et al., 2014). A treatment approach which is not whole disorder based is therefore particularly important. There has been a recent call to focus on developing novel psychotherapeutic approaches after trauma, including treatments that target memory processes and which can be delivered by non-specialists (Hoge & Chard, 2018). To adequately support healthcare staff following exposure to work-related trauma, we need novel interventions which are effective, brief, accessible, low-stigma and scalable, and can be used repeatedly to manage ongoing trauma exposure.

A novel, brief, low-intensity imagery-competing task intervention to target intrusive memories of trauma has recently been developed (Holmes et al., 2009). The intervention is a

single session (approximately 25 minute) task procedure, administered with researcher support, which thereafter can be self-administered as needed. The intervention involves several key components: a) bringing to mind the visual memory of the trauma, in order to re-activate the specific trauma 'hotspot' (Grey & Holmes, 2008), then b) playing the visuospatial computer game Tetris (e.g., for at least 20 minutes), after c) training to engage in 'mental rotation' throughout to optimise visuospatial demand (Singh et al., 2020). The aim is to reduce the number of times intrusive memories recur. This brief cognitive intervention has now been tested soon after trauma in three randomised controlled trials (RCTs) in a range of trauma samples: women who experienced traumatic childbirth (Horsch et al., 2017), motor vehicle accident survivors in the emergency department (Iyadurai et al., 2018) and a mixed trauma sample of individuals who presented to the emergency room (Kanstrup et al., 2021). In all three trials, participants reported a significantly greater reduction in the number of intrusive memories in the first week post-trauma in the intervention versus control condition. The effect sizes range from small to medium: d = 0.43, 95% CI: -0.23, 1.08 (Kanstrup et al., 2021); d = 0.65, 95% CI: 0.11, 1.18 (Horsch et al., 2017); d = 0.67, 95% CI: 0.18, 1.14 (Iyadurai et al., 2018). In addition to reducing the number of intrusive memories, there is also evidence that the intervention has a significant impact on key intrusion characteristics. Specifically, relative to individuals who presented to the emergency room and were allocated the control condition, those who received the intervention reported less intrusion-related distress and vividness at one week post-intervention (distress: d = 0.45, 95% CI: -0.33,1.22; vividness: d = 0.48, 95% CI: -0.30, 1.26; Kanstrup et al., 2021).

There is also evidence suggesting that the intervention has the potential to reduce older, established trauma memories from experimental and clinical studies (James et al., 2015; Kanstrup et al., 2020; Kessler et al., 2018). James and colleagues (2015) found a significant reduction in intrusive memory frequency in the following week when the

intervention versus control was delivered 24 hours following experimental trauma (traumatic film viewing). In a case series with four trauma-exposed individuals who were refugees, Kanstrup et al. (2020) reported decreased intrusive memory frequency and functional improvements (e.g., improved concentration) over three weeks. In a sample of inpatients (n = 20) with chronic complex PTSD, the number of intrusive memories targeted with the intervention reduced by an average of 64% from baseline to post-intervention (Kessler et al., 2018). Notably, these effects were specific to targeted memories; by comparison, intrusive memories which were not targeted decreased by 11% over the same period.

The mechanism of the intervention is based on theories of memory consolidation/reconsolidation and 'dual task' interference. Memory consolidation is the process which occurs following learning and promotes the laying down of lasting 'fixed' memories (Debiec, 2012; Kessler et al., 2017). Prior to memories reaching their stable form, there is a period of several hours immediately after learning and encoding where synaptic changes, including long-term potentiation, act to stabilise the memory trace (Debiec, 2012). During this period, while trauma memories are labile, performing a visuospatial task which taxes the visuospatial sketchpad of the working memory is proposed to compete for the limited capacity via a process of interference and disrupts the consolidation of visual aspects of the trauma memory, resulting in fewer subsequent intrusive memories (Singh et al. 2020). Similarly, it has been proposed that it is possible to target older, established memories by disrupting memory r*econsolidation*, which is defined as "the process by which memories can become destabilised at retrieval, and be updated or modified" (Vousden & Milton, 2017, p. 158). Reconsolidation theory suggests that previously consolidated memories may be reactivated through a retrieval cue, become malleable, and a possible updated version of the original memory trace can be applied (Nader et al., 2000). Both memory reactivation *and*

playing Tetris were necessary to reduce subsequent intrusions, which is consistent with a 'reconsolidation-update' mechanism hypothesis (Schiller et al., 2010).

In this study, we aimed to test, for the first time, the efficacy, feasibility, and acceptability of the brief behavioural intervention to target established memories of trauma in a population of NHS clinical staff, such as nurses, doctors, and paramedics, who had been exposed to traumatic events within their line of work, including during the COVID-19 pandemic. Clinical healthcare staff have often experienced multiple traumatic events at work (as opposed to a single trauma), and additionally, they are exposed to frequent and ongoing traumatic events as part of their work. Therefore, traditional trauma-focused treatments are often not well-suited. The primary aim was to determine whether the intervention could reduce the number of intrusive memories of work-related traumatic events. We predicted that there would be a significant reduction in the number of intrusive memories from the baseline period to the post-intervention period. A secondary aim was to investigate whether there would be a change in a) intrusive memory characteristics such as vividness and distress, and daily functioning, and b) other mental health symptoms, namely posttraumatic stress, depression and anxiety symptoms, from first to final session. A tertiary aim was to investigate whether the brief cognitive task intervention is a feasible and acceptable intervention for NHS clinical staff.

Method

Participants

The participants in this study were clinical NHS staff (including doctors, nurses, paramedics) working in hospital and pre-hospital departments (e.g., emergency department, intensive care unit, ambulance services team) at Oxford University Hospitals (OUH) NHS

Foundation Trust, Royal Berkshire NHS Foundation Trust and South Central Ambulance Service (SCAS) NHS Foundation Trust.

Inclusion criteria[3] were as follows: aged 18 or above; able to read, write and speak in English; an NHS hospital or pre-hospital clinical staff member; reporting the occurrence of at least two intrusive memories (self-rated as problematic) of a work-related traumatic incident in the seven days prior to beginning the study; able and willing to: provide informed consent and complete study procedures; talk about the intrusive memories; complete a daily electronic intrusive memory diary over a 2-3 week period; play Tetris on a hand-held device; and, not currently undergoing treatment for PTSD or its symptoms. Participants were excluded if they had fewer than two intrusive memories[4] per week during the pre-intervention period, or if they started undergoing treatment for PTSD or its symptoms during the course of the study.

Design

In this case series we employed an AB single-case experimental design methodology (Barlow & Hersen, 1984; Morley, 2018) to investigate the efficacy of the brief cognitive task intervention. The primary outcome was the change in the number of intrusive memories of traumatic events from baseline to post-intervention. The baseline period 'A' was the period prior to the first administration of the intervention, i.e., monitoring-only, and post-intervention period 'B' was anytime thereafter. The minimum baseline period was seven days; the maximum was three weeks. The total study duration varied for participants from five to eight weeks, owing to changes in the study design following the COVID-19 pandemic. Details of the different study design and reasons for changes are described below.

[3] The inclusion and exclusion criteria listed here are the most up-to-date version of the study design, i.e., those that apply to P3-P14. For earlier inclusion and exclusion criteria corresponding to earlier study designs, please see Appendix 10.

The initial design was a between-subjects multiple baseline AB design (Barlow & Hersen, 1984), in which participants were randomised to a 3- or 5-week pre-intervention period. Following initial difficulties with recruitment and the onset of the COVID-19 pandemic, the overall duration of the study period was reduced to improve recruitment opportunities[5] and minimise burden on healthcare staff. The study design was amended three times. As a result, P1 completed a six-week study design (three-week baseline period and targeting a single intrusive memory with a one-off researcher administered intervention), P2 completed an eight-week study design (three-week baseline period and targeting up to three intrusive memories with a one-off researcher administered intervention per intrusive memory), and P3 to P14 completed a five-week design (one-week baseline period, a researcher administered intervention targeting the most frequent and bothersome intrusive memory and the possibility to target this and other intrusions as many times as needed (for example, if they recurred), and a one-month follow-up). See section *'Intrusive memory monitoring and weekly questionnaires'* and Figure 1 below for a diagrammatic representation of the different participants' study designs, including timepoints of outcome measurement. Given that the overall single-case AB design remained the same across participants, results were analysed together for all participants.

Sample size

Fourteen participants took part in the study (recruited from February 2020 to September 2020). Tarlow (2017) suggested that in case series where the number of participants is fewer than seven, Tau fails to detect even a high degree of trend in the baseline. Thus, a minimum of eight participants was initially set, as it was deemed sufficient to detect reliable trends in the data and for adequately powered statistical analyses.

[5] Exploring some of the reasons for poor initial uptake into the study (e.g., busy clinical staff) with the study collaborators (e.g., ED research nurses), it was predicted that shortening the study period would make the study less burdensome for already busy clinical staff and improve recruitment rates.

Additionally, given that a brief cognitive intervention had not yet been tested on a population of healthcare workers and thus, the frequency and homogeneity of the population's intrusive memories was unknown, eight participants was deemed appropriate to begin to understand the trends in intrusive memory frequency among this population. A maximum of 20 participants was pre-determined, in line with Kessler and colleagues (2018) work.

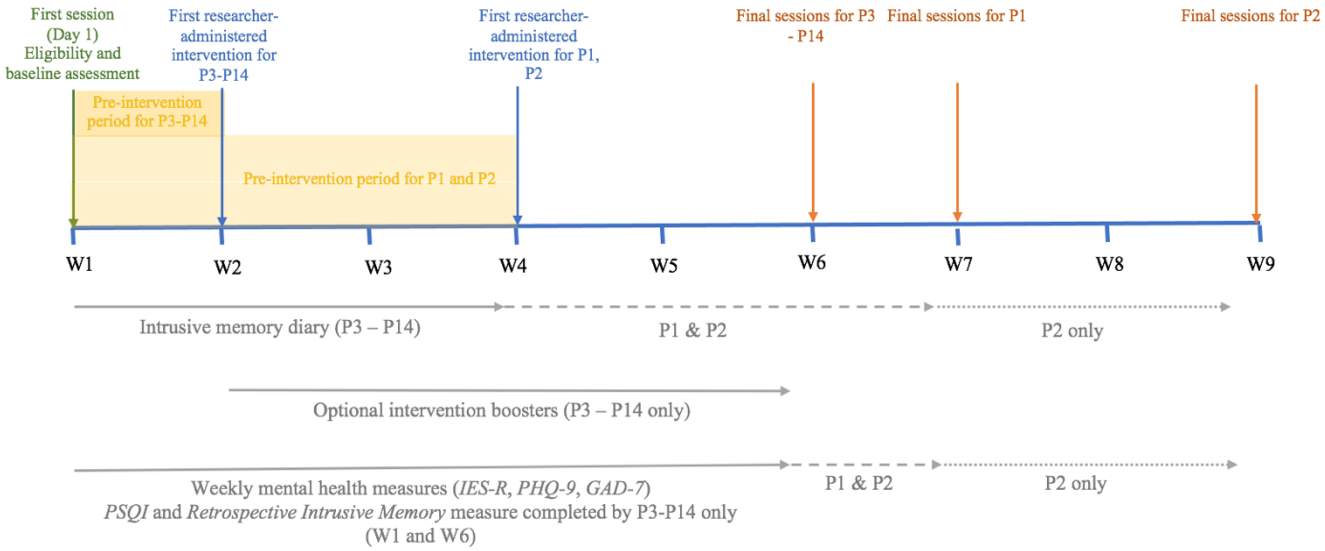


Figure 1. A study timeline for P1, P2, and P3-P14. Shown are the first and final session, the duration of the pre-intervention and intervention periods, and completion of the primary and secondary outcomes over the study weeks 1 – 9 (W1 – W9).

Measures and materials

Sociodemographic information

Participants provided details about their gender, age, years in education, marital status, ethnicity, job role, banding level, and length of employment at their clinical department (see Appendix 11).

Baseline information about traumatic events and intrusive memories

List of intrusive memories

Participants' intrusive memories were recorded in a form in an online survey platform software Qualtrics (2020) by the researcher (e.g., using 'share screen' if meetings were conducted virtually; see Appendix 12). Participants were asked how many work-related

traumatic events they were currently experiencing intrusive memories of, and how long ago each of these traumatic events took place (in years and months). Participants were verbally given the following definition of intrusive memories: "*vivid, emotional memories of the incident that 'pop' into mind without warning, often taking the form of visual pictures in the mind's eye, for example a snapshot image or a film clip*". They were also informed that intrusive memories can include other senses (such as sounds and smells), that they may or may not be triggered by something the person is aware of (e.g., telling someone about the incident or being back at the scene), and that intrusive memories can be "*very short, fleeting and broken up*". The researcher explained that deliberately thinking about an incident or mulling it over or having general thoughts about it without an image, for example, "*I was involved in a failed resuscitation*", did not constitute an intrusive memory (Iyadurai et al., 2018; Kessler et al., 2018). Participants were then asked to briefly list their intrusive memories and were given the following verbal instruction: "*Please briefly describe the worst moments of the traumatic event(s), e.g., an image or a sound. It is fine to summarize them in just a few words."* Participants were asked to label each intrusive memory by selecting a few keywords (e.g., 'cardiac monitoring machine') to describe its content. These keywords were later used to aid the intrusive memory diary completion. Finally, they were also asked to identify which one intrusive memory is commonly the most frequent and bothersome, which would later be targeted with the intervention.

Primary outcome measure

Intrusive memory diary

Participants recorded the number of intrusive memories experienced each day in a diary (see Appendix 13) which was adapted from paper diaries used in previous studies (e.g., Iyadurai et al. 2018; Kessler et al., 2018; James et al., 2015) and delivered online using Qualtrics (2020). Participants accessed the diary electronically via a link sent securely to their

email address. Participants were also sent daily automated text messages (at a time of their choosing) which included the link to the diary and reminded them to complete it. After clicking on the link, they were instructed to select, from a drop-down menu of their own intrusive memories, which of the intrusive memories they had experienced since they last completed the diary. They were also asked to indicate how many times they had experienced that memory by typing in the relevant number. If they experienced a new intrusive memory that had not previously been identified they had the option to select 'Other'. Participants were encouraged to record intrusive memories as soon as possible after they occurred, but at least once per day. If no memories were experienced that day, participants were asked to indicate this by recording 'zero'.

For each intrusive memory, participants were asked to record the approximate time the intrusive memory came into mind, rate intrusive memory characteristics (i.e., vividness and distress), and impact of the intrusive memory (e.g., sleep and concentration disruption). As these were exploratory outcomes, further details of the items and results are given in Appendix 14. Participants were also asked whether they were at work at the time of the intrusive memory (*yes*, *no*), how many times they had used the intervention since the last diary entry (entered as an exact number or *not at all*), and how accurately they thought they had completed the diary (0 = *not at all*, 10 = *extremely*).

Secondary outcome measures: Intrusive memory characteristics and functioning

Retrospective ratings of intrusive memory characteristics and impact on functioning

A 10-item rating scale (see Appendix 15) which assesses the characteristics of intrusive memories and their impact on functioning, was rated retrospectively ('over the past week') and completed twice, once at the first session and once at the final session. Participants provided ratings of the number of intrusive memories (*none (0), some (1-4), quite a few (5-*

10), lots (11-20), very many (21-30), a large amount (31-50), more than 50), as well as their vividness (0 = *not at all*, 10 = *extremely*), associated distress (0 = *not at all*, 10 = *extremely*), the extent to which they disrupted concentration (0 = *not at all*, 10 = *a great deal*), the extent to which they disrupted the task at hand (0 = *not at all*, 10 = *a great deal*), the duration intrusive memories were bothersome (*<1 min*, *1-5 min*, *6-10 min*, *11-30 min*, *31-60 min*, *>60 min*), the extent to which they interfered with sleep at night (0 = *not at all*, 10 = *a great deal*) and the degree to which they affected their ability to function in daily life (0 = *not at all*, 10 = *a great deal*). Participants also indicated the ways in which their ability to function in daily life was affected by intrusive memories (open-ended response).

The Pittsburgh Sleep Quality Index (PSQI; Buysse, 1989)

The PSQI (Buysse et al., 1989) is a self-report measure of sleep quality over a 1-month time interval. It consists of nine questions, which produce one global score. A score above five indicates significant difficulties with sleep (Zhong et al., 2015) The PSQI has a good internal consistency (Cronbach's alpha = .83) and test-retest reliability (r = .85; Germain et al., 2004). This questionnaire was administered at the first and final session with the participant.

Secondary outcome measures: Mental health symptoms

Impact of Events Scale–Revised (IES-R; Weiss & Marmar, 1997)

The IES-R is a 22-item measure of subjective distress experienced after traumatic events. It comprises three subscales (intrusion, avoidance and hyperarousal). Items are rated on a scale from 0 (*not at all*) to 4 (*extremely*). A total maximum score is 88, with a score of ≥33 representing a cut-off for a probable diagnosis of PTSD (Creamer et al., 2003). The measure has a high internal consistency (α = .96; Rash et al., 2008) and good test-retest reliability, ranging from .89 to .94 (Creamer et al., 2003). The IES-R has been deemed to be sensitive to a general construct of traumatic stress in populations with lower symptom levels

(Creamer et al., 2003). This questionnaire was administered weekly from first to final session.

The Patient Health Questionnaire Depression scale (PHQ-9; Kroenke et al., 2001)

The PHQ-9 is a 9-item measure of depression symptoms and their severity. Items are rated on a 4-point Likert-type scale, ranging from 0 (*not at all*) to 3 (*nearly every day*). The total maximum score is 27. A score of ≥10 has 88% sensitivity and specificity for major depression. The PHQ-9 had been found to have excellent internal reliability (Cronbach α = .89) and test-retest relatability has been reported as 0.89 (Kroenke et al., 2001). Validity has been demonstrated in the non-clinical population (Martin et al., 2006). This questionnaire was administered weekly from first to final session.

The Generalised Anxiety Disorder scale (GAD-7; (Spitzer et al., 2006)

The GAD-7 is a 7-item measure of symptoms of general anxiety disorder (GAD) and their severity. Items are rated on a 4-point Likert-type scale, ranging from 0 (*not at all*) to 3 (*nearly every day*). The total maximum score is 21, with a score of ≥10 being indicative of GAD. The measure has excellent internal consistency (Cronbach α = .92) and good test-retest reliability (r = 0.83; Spitzer et al., 2006). This questionnaire was administered weekly from first to final session.

Tertiary outcome measures: Acceptability of the intervention and feasibility of study procedures for NHS clinical staff

Participant feedback questionnaire

An 11-item feedback questionnaire (see Appendix 16), adapted from Iyadurai and colleagues (2018), was administered to ascertain the acceptability of the intervention and feasibility of the study procedures. Items assess participants' experience of completing the intervention (i.e., how easy, helpful and burdensome they found it), their willingness to use the intervention if it was offered to them in the future (i.e., in the event that they experienced

any further intrusive memories), and their confidence in recommending the intervention to a colleague who was experiencing intrusive memories (all rated from 0 = *not at all*, 10 = *extremely*). Participants also answered open-ended questions about their experience of the intervention and taking part in the study (e.g., any suggestions they might have for improvements, any other comments they might have about the intervention or the study generally). This questionnaire was completed at the final session.

Rates of treatment adherence, outcome measure completion and attrition

Treatment adherence, outcome measure completion and attrition were recorded to indicate the feasibility of these aspects of the study.

Duration of Tetris gameplay

The length of time that participants played Tetris was recorded for all researcher-administered intervention sessions.

Intervention

The brief behavioural intervention consisted of a single session comprising three components: a) a memory reminder procedure to reactivate the trauma memory, b) engaging in a visuospatial interference task, i.e., playing the computer game Tetris, and c) using specific 'mental rotation' instructions to play the game. The memory reminder procedure consisted of participants briefly bringing the selected intrusive memory to mind and writing down its contents in first person narrative on a blank piece of paper[6]. Participants were asked to write only as much detail as was necessary to recall the event, but without it becoming too emotionally overwhelming. This differentiates the procedure from that of 'reliving', in which the traumatic experience is recounted in detail as is typically part of trauma-focused CBT treatment (Ehlers & Clark, 2000). Tetris is a well-

[6] The hand-written excerpt was shredded by the participant immediately after the intervention session and its contents were not read by or discussed with the researcher.

known simple computer game which involves rotating coloured shapes which fall from the top of the screen to form horizontal lines of blocks at the bottom. Participants were given instructions on how to use mental rotation i.e., visualising in the 'mind's eye' how to rotate and move the Tetris blocks to make horizontal lines. In order to increase the visuospatial demands of the game, participants were asked to plan ahead and work out how to place the next blocks coming up as well as the one being played to complete the horizontal lines (Iyadurai et al., 2019; James et al., 2015). After receiving instructions, and a demonstration from the researcher, participants practiced the game until the researcher could see that they clearly understood the instructions and were using mental rotation. Participants played Tetris for at least one uninterrupted period of 10 minutes, and for approximately 25 minutes in total (Kanstrup et al., 2021). Participants were asked to restart the game if 'game over' was reached (Kessler et al., 2018). The researcher had received thorough training in delivering the procedure (see Appendix 17).

Devices used to access Tetris

The visuospatially-demanding computer game Tetris was played on a Nintendo DS XL by P1. Due to the COVID-19 pandemic resulting in national lockdown measures, the intervention was delivered remotely to the remaining participants, via the official Tetris website (https://tetris.com) accessed on their mobile phone or tablet computer (for instructions see Appendix 18).

Intervention compliance

Within-intervention arousal level

A bespoke 11-point Likert-type scale was administered to measure participants' subjective level of arousal, on a scale of 0 (*calm*) to 10 (*maximum arousal*). It was administered at three time points during each researcher-administered intervention session: before and after a memory reminder procedure, and after playing Tetris (described in the

'Intervention' section below) and recorded by the researcher in Qualtrics (2020). The purpose of delivering this measure was 1) to ensure that the memory reminder procedure had reactivated the trauma memory sufficiently to make the consolidated memory labile for reconsolidation but not so much as to be highly distressing, and 2) to check for potential immediate effects of the intervention (e.g., a reduction in arousal rating possibly relating to a decrease in distress; Kessler et al., 2018).

Procedure

Ethical approval for the study was granted by the Health Research Authority (HRA) and University of Oxford Medical Sciences Inter-Divisional Research Ethics Committee (MS IDREC). Sponsorship was provided by University of Oxford Clinical Trials Research Governance (CTRG) and funding was provided by the Oxford Institute of Clinical Psychology Training and Research (OXICPTR) and the University of Oxford John Fell Fund. Trust Management approval was provided by OUH, Royal Berkshire and SCAS NHS Foundation Trusts (see Appendix 19). The study was registered under ClinicalTrials.gov NCT04769999[7] and can be accessed from: https://clinicaltrials.gov/ct2/show/NCT04769999?term=CALM-ED&draw=2&rank=1. A record was created on the 13th July 2020, ahead of P4 being recruited and once the final study design was approved, however there was a delay resulting in the record not being publicly released until 25th February 2021, part way through data analysis.

[7] The study registration states the following time frame for the primary outcome measure: "The baseline period and the post-intervention period were defined separately for each intrusive memory, according to when that intrusion was first targeted with the intervention." Following a viva condition from my examiners which recommended a change in the analysis of the data, the baseline, 'A', is now defined as the period prior to the first administration of the intervention, i.e., monitoring-only, and is not defined separately for each intrusive memory.

Recruitment

The study was advertised in a number of ways: 1) study researcher (VK) verbally presented the study at hospital ward handovers and team meetings, 2) advertisement emails were sent out to staff, 3) study information was disseminated verbally and electronically via Trust research team members, 4) posters and leaflets were put up in staff frequented areas around the hospitals, e.g., common rooms, as well as electronically via Trust intranets. Sample recruitment materials are in Appendix 20. The researcher's contact details were provided in all advertisements, emails and face-to-face communications. Potential participants who were interested in the study contacted the researcher (VK) via email or telephone. They were sent the participant information sheet (see Appendix 21) via email, and given the opportunity to question the researcher, their GP or other independent parties to decide whether they wished to participate in the study. Figure 2 below depicts an adapted CONSORT flow diagram for the study.

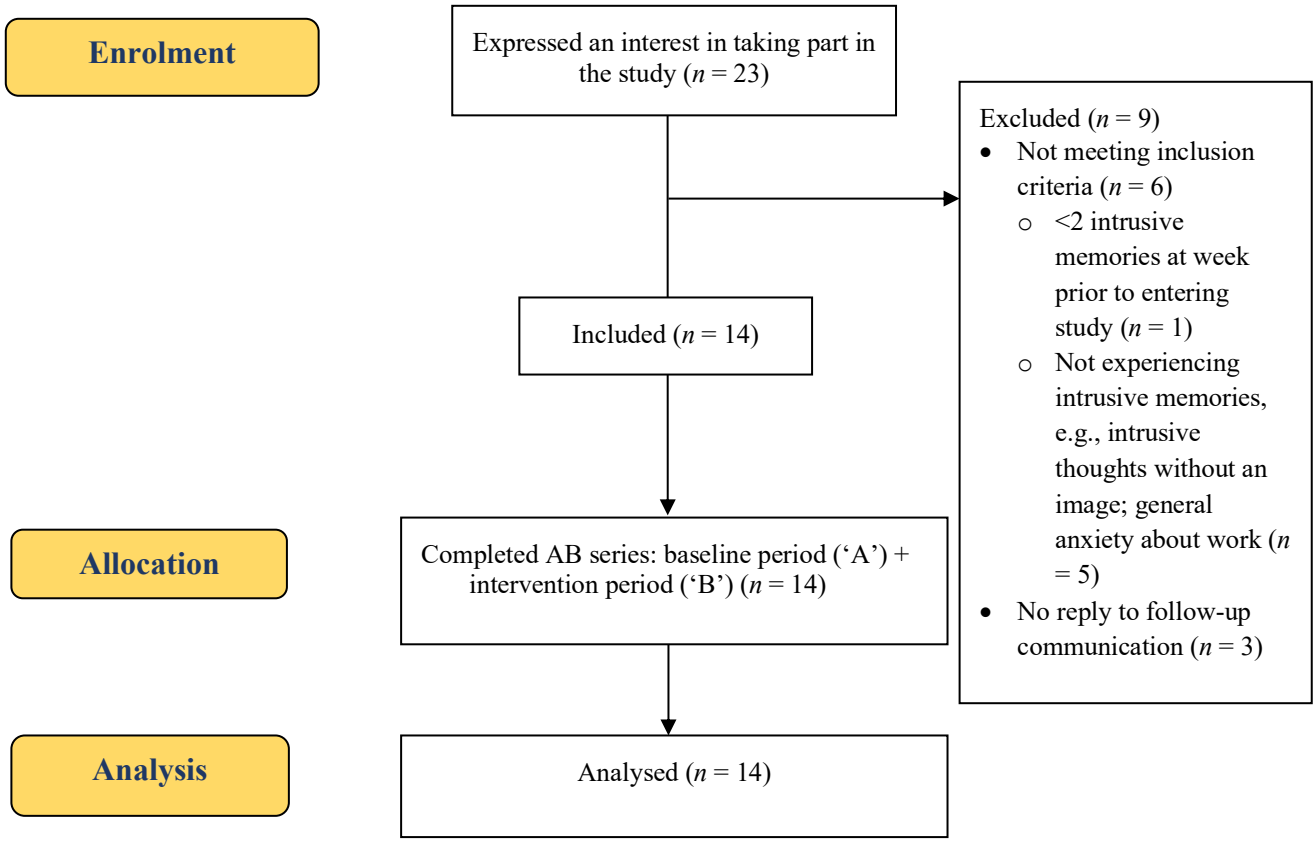


Figure 2. Adapted CONSORT flow diagram for the study.

First session

Eligibility and informed consent

If participants were interested in taking part, the researcher arranged to meet with them (in person for the first two participants, and by video call for the remaining participants following the onset of the pandemic) to assess their eligibility and complete informed consent procedures. If the participant met the study inclusion criteria, informed consent was obtained (written informed consent for the first two participants and consent obtained verbally via video call for the remaining participants due to social distancing; Appendix 22 contains the verbal informed consent form).

Baseline assessment

Prior to commencing study procedures, all participants were provided with information about local occupational and mental health support services (see Appendix 23). Participants' personal information was recorded by the researcher in an encrypted electronic form (see Appendix 24). The participants subsequently completed the Sociodemographic Information form and baseline measures (IES-R, PHQ-9, GAD-7 and PSQI) in Qualtrics (2020). The researcher then completed the Retrospective Intrusive Memory measure with participants. The List of Intrusive Memories form was then used to gather a brief description of participants' intrusive memories. The participants were asked to indicate which one of their intrusive memories they experience as the most frequent and bothersome, and hence, the one that we would target with the intervention. After completing the forms and baseline measures, participants were given verbal instructions on how and when to complete the intrusive memory diary. Specifically, P1 and P2 were instructed to record all of their intrusive memories in the daily diary for three weeks, and P3-P14 for one week (i.e., monitoring-only period). A simulated diary entry was completed collaboratively with the participant on the researcher's computer and participants were offered the opportunity to

ask questions. An intervention session date was agreed with the participant at the end of the session, to target the most frequent and bothersome intrusive memory. Please refer to Figure 1 for details about when the intervention sessions took place for each participant.

Intervention session

Following the baseline period (week 4 for P1 and P2, and week 2 for P3-P14), the participants met with a researcher for the intervention session. Through a collaborative discussion with the participant and based on review of their diary data over the baseline period, the most frequent and bothersome intrusive memory was confirmed and selected to be targeted with the intervention. The participant then completed the intervention with instruction from the researcher (please refer to p. 87-88 for a detailed description of the intervention procedure). At the end of the intervention session, participants were given instructions for using optional 'intervention boosters', i.e., to target any intrusive memories that recur, in their daily life according to need. These were either self-administered (i.e., playing Tetris *immediately* after they experienced an intrusive memory) or researcher-assisted (by arranging to meet with the researcher to target a recurred intrusive memory using the same procedure as described in the 'Intervention' section on p. 89-90). Participants were able to use the intervention as many times as needed during the post-intervention period. Participants continued recording all their intrusive memories in the daily diary; three weeks for P1, five weeks for P2, and two weeks for P3-P14.

Final session

The final study meeting took place at week seven for P1 (face-to-face), week nine for P2 and at week six for the remaining participants. During this meeting, participants completed the final weekly secondary outcome measures (IES-R, GAD-7 and PHQ-9), PSQI, the Retrospective Intrusive Memory measure (P3-14 only), and the feedback questionnaire. Following completion of the measures, the researcher provided information about the study

aims and objectives and gave participants the opportunity to ask questions about the research. The researcher revisited the signposting information for the relevant agencies that offer support if they continued experiencing bothersome intrusive memories or other symptoms of PTSD. Participants were subsequently reimbursed for their time.

Reimbursement

To thank participants for their time, they were reimbursed £50 either in the form of a bank transfer or a store voucher.

Data analysis

The alpha level of <.05 for statistical significance was set for all two-tailed analyses. Statistical analyses were conducted in IBM SPSS Version 27 (2020).

Participant characteristics

Sociodemographic information and baseline information regarding traumatic events and intrusive memories were summarised using descriptive statistics. To describe the general content of participants' intrusive memories, they were grouped according to common themes.

Primary outcome analyses

Tau-*U*[8] statistic was used to determine the effects of the intervention on between-phase differences, i.e., between the baseline and post-intervention periods (Parker et al., 2011). Individual participant data was examined for evidence of a baseline trend using a web-based calculator (Tarlow, 2016). Following inputting the baseline data into the calculator, the calculator makes a recommendation as to whether to estimate an effect size using an uncorrected Tau analysis, or indeed, whether a baseline-corrected Tau is required. When a baseline trend is found, this indicates that significant changes between data pairs are occurring in the absence of an intervention effect. If a significant change in the trend within

[8] I would like to thank my examiners for the recommendation of using a Tau-*U* analysis at the viva examination. This has amended the way in which the original data was initially analysed, i.e., separately for each intrusive memory, depending on when it was first targeted with the intervention.

the baseline was detected, effect sizes were estimated from the baseline trend-corrected data (Tarlow, 2017; please refer to Appendix 25 for within-phase analyses used to detect baseline trend). Tau-*U* was subsequently calculated using the web-based Tau-*U* calculator (Vannest et al., 2011). Individual phase contrasts between the baseline and the adjacent post-intervention contrast were calculated for each participant. Results were then aggregated into a single omnibus effect size for the series (Morley, 2018; see Appendix 25). Tau-*U* effect sizes are measured as *small* (0-0.65), *medium* (0.66-0.92), or *large* (0.93-1.00; Parker et al., 2009). New intrusive memories which were not reported at baseline assessment, i.e., prior to baseline monitoring commencing, were excluded from the main analysis and they were reported descriptively for both baseline and post-intervention periods.

To determine whether there was a significant decrease in the mean number of intrusive memories from baseline to post-intervention period, the mean number of intrusive memories per day was calculated for each participant. The unit of 'per day' versus 'per week' was chosen to enhance the accuracy of measurement and to scale the unit to the length of P3-P14's week-long baseline period. Thus, baseline and post-intervention daily intrusive memory means were calculated to account for the precise time that the first intervention was given within the 24-hour period, e.g., baseline time = (number of complete baseline days) + (number of hours before intervention was delivered / 24). Baseline mean = number of baseline intrusions / baseline time. Post-intervention period = number of post-intervention intrusions / post-intervention time. Percentage reduction in intrusion frequency from baseline to post-intervention was calculated as [1 – (mean number per day post-intervention/mean number per day at baseline)] * 100] (Kessler et al., 2018).

Visual inspection of individual time-series graphs was carried out to ascertain the pattern of change in the frequency of intrusive memories from baseline to post-intervention (Kazdin, 2019; Morley, 2018).

Secondary outcome analyses

To determine if there were changes in intrusive memory characteristics (i.e., vividness and distress) and impact on functioning (i.e., concentration, sleep, daily functioning), first and final session means and standard deviations of ratings were calculated and presented graphically for visual inspection, and percentage changes from first to final session were given. Categorical data about the frequency of intrusive memories, and for how long intrusions were bothersome, were presented graphically. Qualitative data for the impact on everyday functioning were presented in a table. To further assess changes in sleep, PSQI from first to final session scores were tested for *statistical significance* using paired samples *t*-tests. Reliable change index (RCI) was calculated to determine if the change per individual was *statistically reliable* (Jacobson et al., 1999; Jacobson & Truax, 1991). To ascertain changes in usual sleep habits and overall sleep quality, a global score >5 indicating significant difficulties with sleep was used (Zhong et al., 2015).

To investigate whether there was a change in mental health symptoms, namely post-traumatic stress symptoms, depression and anxiety, first, scores from the first and final session were tested for *statistical significance* using paired samples *t*-tests, or Wilcoxon-signed rank tests (for outcome data that were not normally distributed). For each outcome measure, the baseline period was assessed for stability (see Appendix 26). Second, individual participant scores are presented graphically for visual inspection of change patterns over time. Third, the RCI was calculated to determine if the change per individual was *statistically reliable* (Jacobson et al., 1999; Jacobson & Truax, 1991). Fourth, to ascertain whether a participant showed *clinically meaningful* reductions on overall symptom measures, the proportion of participants meeting clinical cut-offs at first session and final session scores was compared. For post-traumatic stress symptoms, a cut-off score of ≥33 which represents a probable diagnosis of PTSD was used (Creamer et al., 2003). For depression and anxiety,

cut-off criteria of major depression (PHQ-9, ≥10) and probable diagnosis of GAD (GAD-7, ≥10) was used (Kroenke et al., 2001; Spitzer et al., 2006).

Tertiary outcome analyses

To examine the acceptability of the intervention for participants, feedback questionnaire ratings were summarised using descriptive statistics (means, standard deviations and ranges). Responses to open-ended questions regarding the acceptability and feasibility of the intervention and study procedures were examined for themes and examples for each were presented as anonymised quotes.

To assess treatment adherence, the proportion of participants who completed all three parts of the researcher-administered intervention during the first session according to the protocol was calculated. The outcome completion rates per participant were given as percentages. For the primary outcome, this was calculated as the total number of days on which the diary was completed for all participants divided by the total number of days for which the diary should have been completed for all participants multiplied by 100. For secondary outcome measures, this was calculated as the total number of weeks on which each weekly questionnaire was completed for all participants out of the total possible number of weeks on which each weekly questionnaire should have been completed for all participants, multiplied by 100. The accuracy rating for intrusive memory diary completion is given as a mean, standard deviation and range.

As an intervention manipulation check, changes in arousal ratings (pre- to post-memory reminder procedure, and pre- to post-Tetris gameplay) were given as means and standard deviations and were tested for statistical significance using paired samples *t*-tests, or Wilcoxon-signed rank tests (for outcome data that were not normally distributed).

Mean duration of Tetris gameplay was calculated across all researcher-administered interventions for all participants.

Data accuracy checks

Outcome data was checked by an independent rater to ensure accuracy (see Appendix 27).

Results

Participants

Fourteen NHS clinical staff members who were experiencing intrusive memories of work-related traumatic events met the eligibility criteria and were recruited into the study.

Sociodemographic information

Sociodemographic information for the sample is shown in Table 1 below.

Table 1. Participant sociodemographic characteristics (*n* = 14).

Category	***n* (%) / mean (SD)**
Gender, n (%)	
Female	9 (64)
Male	5 (36)
Other	0
Prefer not to say	0
Age, mean (SD)	33.00 (7.41)
(range in years)	(22 – 49)
Education (from first grade), mean (SD)	17.82 (2.60)
(range in years)	(14-22)
Ethnicity, n (%)	
White British	10 (71)
Any other white background	3 (21)
Pakistani	1 (7)
Relationship status, n (%)	
Single	8 (57)
Married/cohabitating	4 (29)
Divorced/separated	2 (14)
Job role, n (%)	
Nursing	6 (43)
Medical doctor	1 (7)
Student (medical, nursing)	2 (14)
Ambulance service team (e.g., paramedic, emergency care assistant)	5 (36)
Department of employment, n (%)	
Emergency department	5 (36)
Adult intensive care unit	2 (14)

Neonatal intensive care unit	1 (7)
Other hospital department	1 (7)
Ambulance service	5 (36)
Length of time working in current job role (months), mean (SD)	64.64 (71.52)
Length of time working in current job role by time categories, n (%)	
(range in months)	(3 – 240)
3 – 12 months	4 (29)
13 – 36 months	3 (21)
37 – 60 months	3 (21)
More than 61 months	4 (29)
NHS banding level, n (%)	
Band 3	2 (14)
Band 5	4 (31)
Band 6	6 (46)
Band 7	1 (8)
Not applicable (medical student)	1 (8)

The sample was predominantly of a white ethnic background. Most participants were nurses. The length of time spent working in the current job role varied significantly, with almost a third of participants being in their job role for a year or less, and a third being in their role for more than five years. Most participants were employed at NHS Band 6 and none were higher than Band 7.

Baseline information regarding traumatic events and intrusive memories

The number of work-related traumatic events, time since traumatic events and number of different intrusive memories reported by participants at the first session are shown in Table 2. There was heterogeneity in the reported time since the traumatic event, with the oldest event for which intrusive memories continued occurring being 15 years previously and the most recent event occurring two weeks before the participant enrolled in the study.

Table 2. Baseline information regarding work-related traumatic events and intrusive memories (*n* = 14).

Baseline information	Mean (SD)	Range	*n* (%)
Number of discrete traumatic events per participant	2.57 (1.83)	1 – 8	
Time since discrete traumatic event (*n* = 36) across all participants			
0-6 months			4 (11%)
7-23 months			12 (33%)
2-4 years 11 months			13 (36%)
5-7 years 11 months			5 (14%)
8-10 years 11 months			1 (3%)
11+ years			1 (3%)
Number of different intrusive memories of work-related traumatic events per participant	5.07 (2.89)	2 – 14	

Eight themes described the content of the majority of participants' intrusive memories as reported at first session (see Table 3 below). Further examples can be found in Appendix 28.

Table 3. Themes describing the content of participants' intrusive memories (*n* = 14).

Theme	*Example*
Fatal injuries and/or witnessed death of babies, children and young people	*"I see a baby lying on a big trolley. The head was facing the wrong way."*
Witnessing death of others, excluding children	*"The patient lying on a driveway where they were flung onto […] A river of blood."*
Gruesome injuries/disfigurement of the human body	*"Her stomach being so distended that you could see the bowel obstruction. Her skin had almost gone black over those areas."*
Threat to self/own life	*"Seeing the patient about to hit me."*
Recognising and/or connecting with the emotion in the face of another	*"My colleagues face when seeing the baby, hearing her retching."*
Witnessing high expressed emotion in others	*"Image of patient's daughter on the floor crying hysterically."*
Absurdity of the situation which defies logic or learned rules about human and societal functioning	*"Seeing myself standing at the side of the bed and the image of the blood coming out of breathing tube."*
Carrying out a medical/nursing procedure	*"I see my hands squeezing saline into her."*

Primary outcome: Mean number of intrusive memories per day

Tau-*U* yielded significant ($p < .05$) small (P2) and medium (P7, P10, P12) effect sizes for four of the fourteen participants. A baseline trend correction was applied to data from P2. An aggregated omnibus analysis yielded a significant ($p < .001$) small effect size (see Table 4 below; see Appendix 25 for Tau-U output, including baseline trend correction for P2). There was an overall reduction of 60% in the mean number of intrusive memories per day from baseline to post-intervention period across all participants (see Table 4 below for individual percentage changes). Figure 3 illustrates the change in the mean number of intrusive memories per day for each participant.

Table 4. Tau-*U* analysis and individual mean percentage reductions. Effect of the intervention by participant ($n = 14$) comparing individual baseline vs. intervention data, and as an aggregated single omnibus effect size. Individual mean percentage reductions per day from baseline to post-intervention are also shown.

Participant	Tau (SD)	*p*	90% CI	% reduction
P1	-0.31 (-0.31)	0.082	-0.61, -0.02	79%
P2*	-0.48 (0.16)	0.003*	-0.74, -0.22	47%
P3	-0.38 (0.26)	0.142	-0.81, 0.05	51%
P4	-0.45 (0.26)	0.090	-0.88, -0.02	92%
P5	-0.35 (0.25)	0.166	-0.77, 0.07	52%
P6	-0.33 (0.26)	0.193	-0.75, 0.09	100%
P7	-0.59 (0.26)	0.021*	-1.00, -0.17	79%
P8	-0.49 (0.26)	0.061	-0.92, -0.06	79%
P9	-0.13 (0.26)	0.633	-0.56, 0.31	47%
P10	-0.70 (0.27)	0.010*	-1.00, -0.25	51%
P11	-0.04 (0.26)	0.891	-0.47, 0.40	22%
P12	-0.65 (0.26)	0.013*	-1.00, -0.22	64%
P13	-0.09 (0.26)	0.733	-0.52, 0.34	10%
P14	-0.37 (0.27)	0.169	-0.82, 0.07	65%
Aggregated omnibus analysis	Tau (variance)			95% CI
Weighted average	-0.38 (0.07)	<.001		-0.52, -0.25

Note: A single asterisk represents statistically significant AB comparisons at $p < .05$ level. A double asterisk represents baseline corrected data.

Of fourteen participants, four reported new intrusive memories which were not reported at the baseline assessment. See Table 5 for descriptive statistics of the new intrusive memories per participant.

Table 5. Frequency of new intrusive memories by participant (n = 4).

Participant	Number of new intrusive memories	Frequency at baseline	Frequency at post-intervention
P1	1	1	0
P11	1	0	1
P12	5	4	2
P14	1	2	0

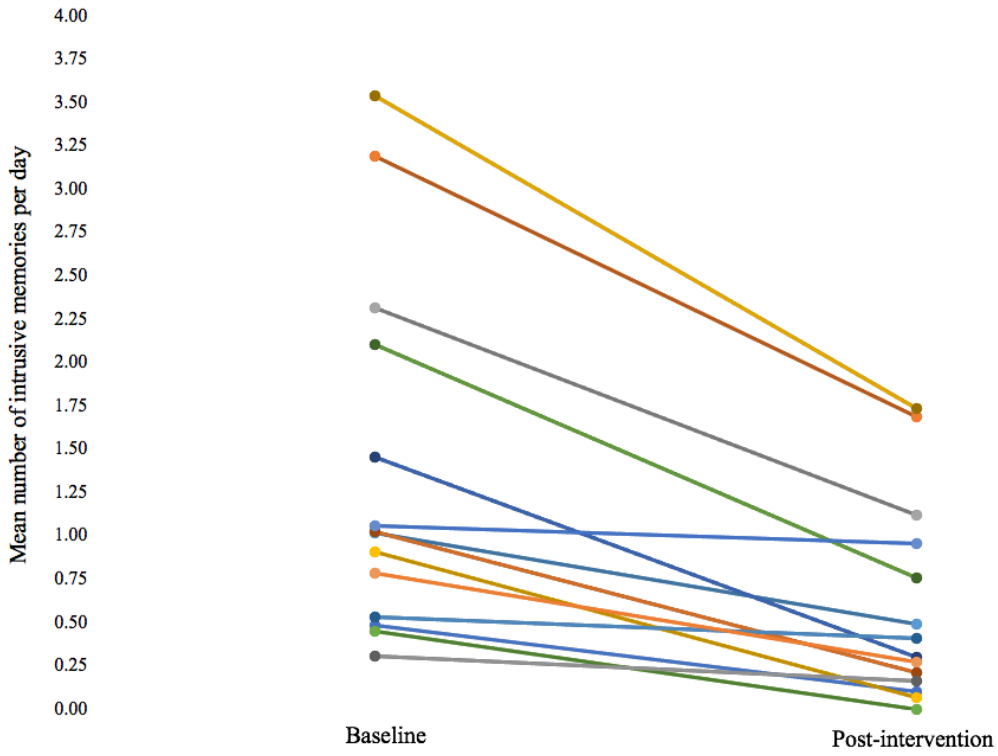
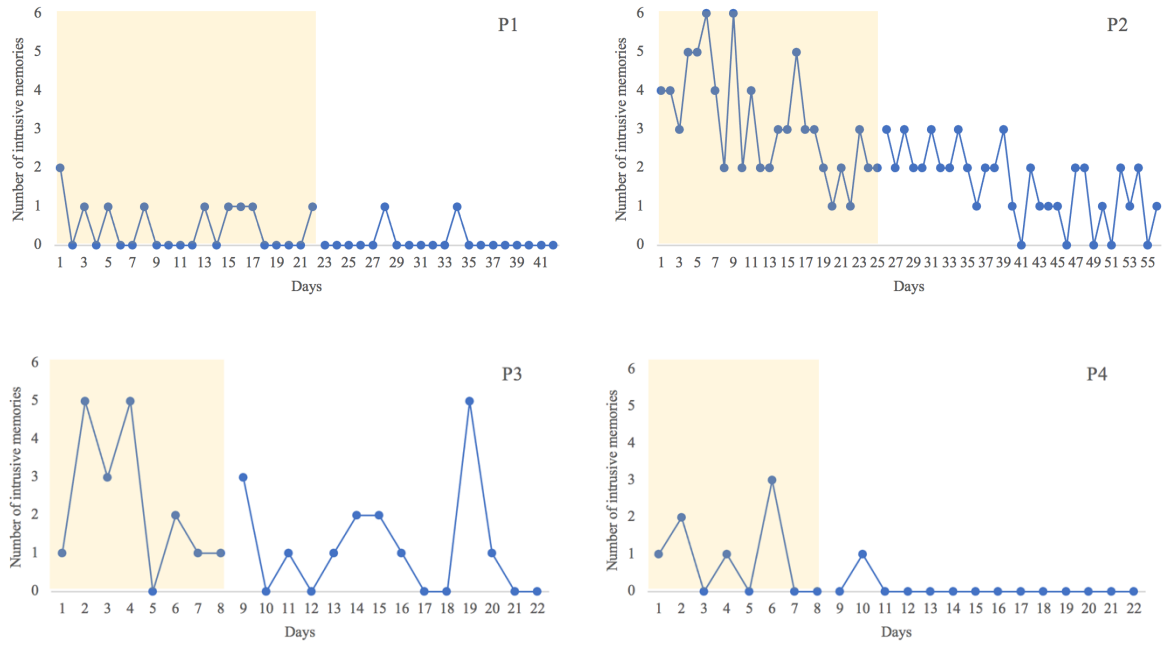
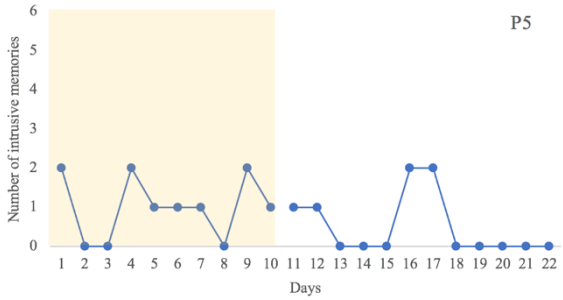


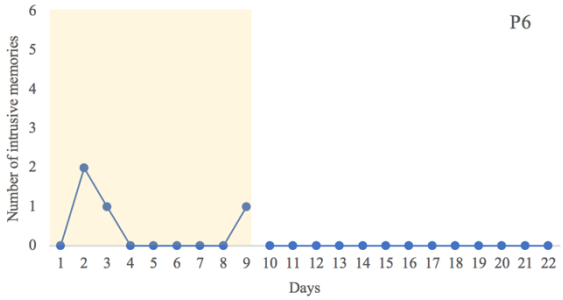
Figure 3. Mean number of intrusive memories per day for the baseline and post-intervention period (n = 14). All participants showed a reduction in their intrusive memories from baseline to post-intervention.

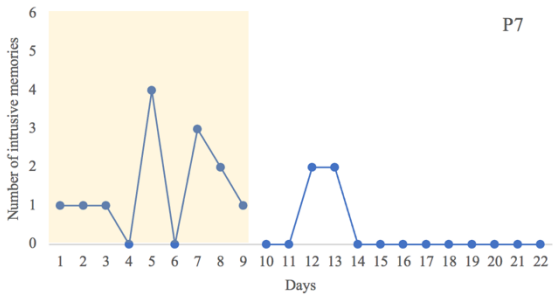
Visual inspection of graphs (Kazdin, 2019; Morley, 2018), indicated a reduction in the number of intrusions following the delivery of an intervention (illustrated by the end of the yellow shaded area; see Figure 4). Generally, the number of the intrusive memories decreased either immediately or several days after the first intervention was delivered. Some emerging evidence for the maintenance of zero intrusive memories can be seen for P4 – P7, whose intrusions did not return for the consecutive final five days of the study. This length of time

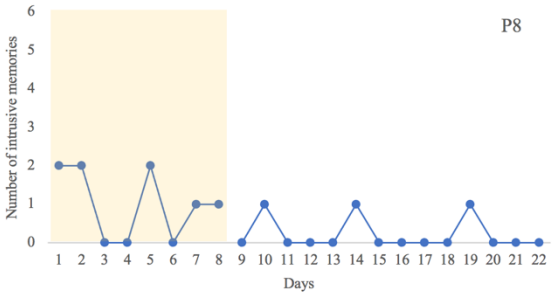
being intrusion-free had not been observed at any other point during their time in the study. Participants 3, 11 and 13 do not appear to follow this pattern, they saw a continuation or re-emergence of intrusive memories in the post-intervention period, similar to that of their corresponding baseline. P3 reported a number of intrusive memories during an unusually stressful period at work, which coincided with the intervention period. The stress included a highly taxing day during the height of the COVID-19 pandemic, including re-deployment to a COVID ward, which correlates with the sharp peak in P3's intrusions on day 19. P3 and P11 all reported functional improvements both at work and in their social life, despite the modest reductions in their intrusions. These improvements were also observed by P13, despite demonstrating a slight increase in intrusions in the post-intervention versus baseline period. Individual level data allowing for visual inspection of patterns of change in intrusive memory frequency are presented as time series graphs in Figure 4.

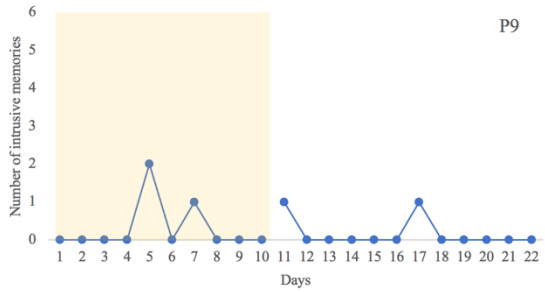


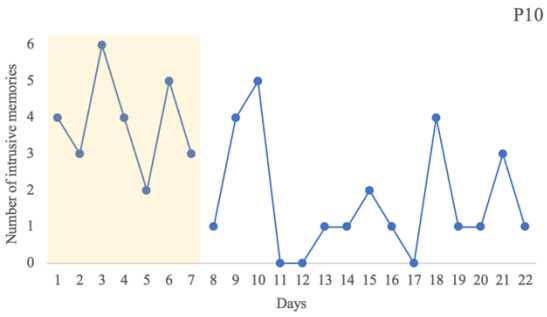

P5
Number of intrusive memories
Days

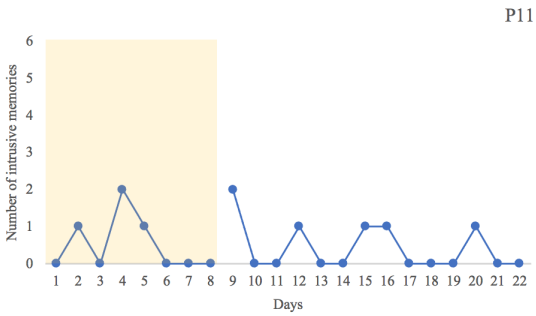

P6
Number of intrusive memories
Days

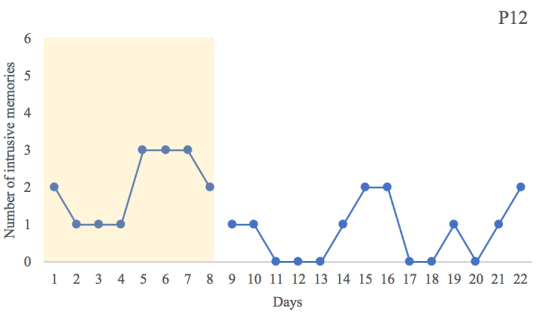

P7
Number of intrusive memories
Days

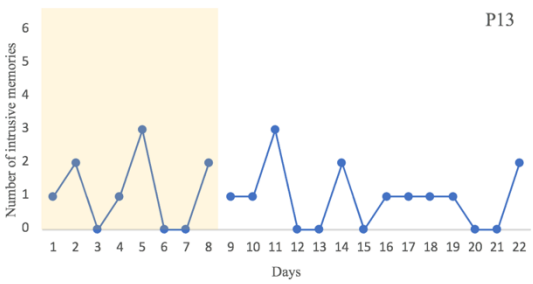

P8
Number of intrusive memories
Days


P9
Number of intrusive memories
Days


P10
Number of intrusive memories
Days


P11
Number of intrusive memories
Days


P12
Number of intrusive memories
Days


P13
Number of intrusive memories
Days

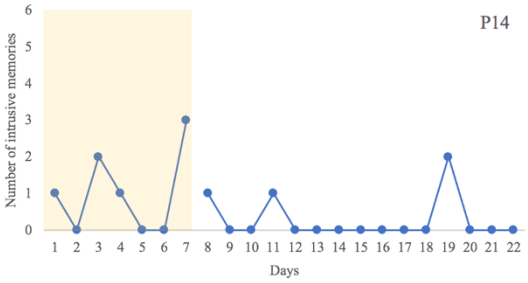

P14
Number of intrusive memories
Days

Figure 4. Individual participant time courses for visual inspection of primary outcome data (total number of intrusive memories; $n = 14$). The number of intrusions per day (y-axis) is plotted against each day of the study period (x-axis). The baseline period (time before the intervention is first delivered) is represented by the yellow shaded area on the graphs. See Appendix 29 for time course graphs illustrating individual intrusive memory trajectories per participant.

Secondary outcomes: Intrusive memory characteristics and functioning

Thirty-nine percent of all intrusive memories across participants occurred whilst they were at work. Figure 5 depicts categorical changes in numbers of intrusive memories reported by participants at first and final session using a retrospective rating for the past week as recorded by the Retrospective Intrusive Memory measure. Visual inspection of Figure 5 shows that at final session, four participants reported no intrusive memories in the week prior.

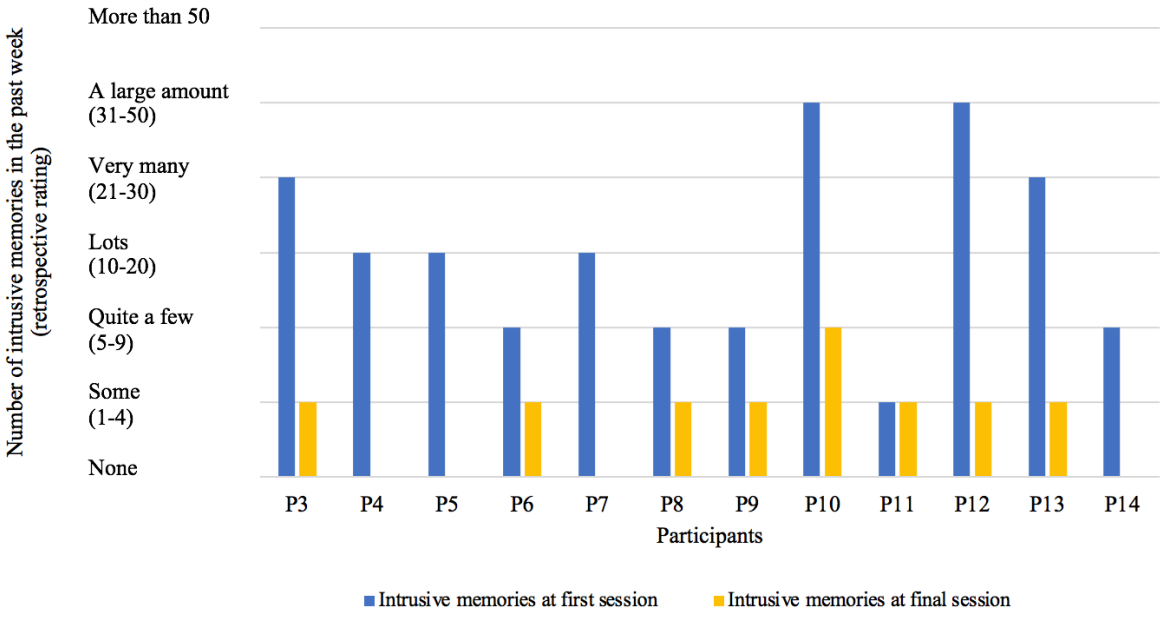


Figure 5. Number of intrusive memories in the past week (retrospective rating) for participants three to fourteen at first and final session ($n = 12$). Where a yellow bar is absent indicates that no intrusive memories were reported over the previous seven days.

Table 6 represents mean ratings of intrusive memory distress, vividness, concentration and task disruption for participants three to fourteen who were administered the Retrospective Intrusive Memory measure at first session and final session. There was a 41% reduction in vividness, a 47% reduction in distress, a 57% improvement in concentration, a 59% reduction in task disruption, and a 47% and 72% reduction in intrusive memories interfering with night's sleep and daily functioning, respectively. Table 6 also shows sleep outcomes at first and final session. Statistical analyses of global PSQI scores and PSQI sleep quality were carried out for participants three through to fourteen (n =12). Global scores on the PSQI at first and final session indicated that five out of eleven (45%) participants experienced significant sleep difficulties (global score >5) at final session compared to nine out of twelve participants (75%) at first session. Across all participants, the mean global PSQI score and the PSQI sleep quality score improved by 13% and 29% respectively, from first to final session. Ratings of the length of time that intrusive memories were bothersome for over the previous week at first and final session can be seen in Figure 6.

Table 6. Retrospective (over the previous week) ratings of intrusive memory characteristics and sleep outcomes at first session and final session (n = 12).

Continuous outcome	First session	Final session			
	Mean (SD)	Mean (SD)			
Vividness	7.63 (1.72)	4.50 (1.51)			
Distress	5.17 (1.47)	2.75 (1.58)			
Concentration disruption	5.58 (2.11)	2.38 (1.77)			
Task disruption	3.92 (1.93)	1.63 (1.60)			
Night's sleep interference	3.27 (3.04)	1.75 (3.62)			
Daily functioning interference	3.55 (2.38)	1.00 (1.41)			
				Effect size	
			Analysis	d	95% CI for d
PSQI global	8.27 (5.10)	7.36 (5.63)	$t(10) = 1.01$, $p = .336$	0.31	-0.31, 0.90
PSQI sleep quality	1.64 (0.92)	1.18 (0.98)	$t(10) = 2.19$, $p = .053$	0.66	-0.01, 1.30

Note: Due to missing data, the PSQI mean final session score is calculated using scores from participants (n = 11). CI = confidence intervals; PSQI = The Pittsburgh Sleep Quality Index; SD = standard deviation.

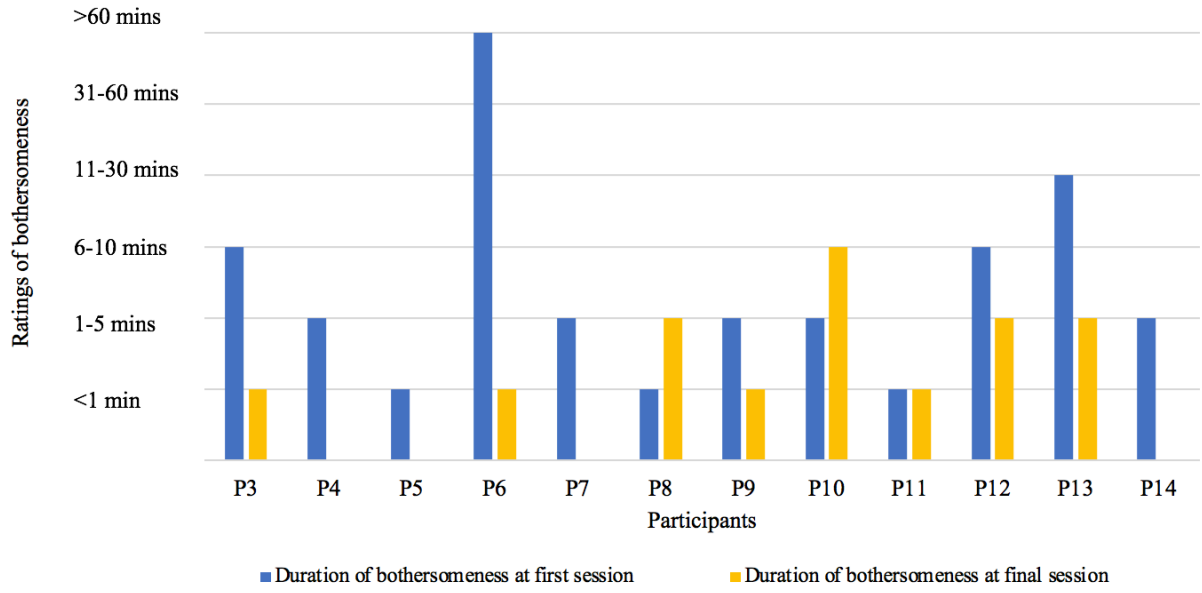


Figure 6. Length of time that intrusive memories were bothersome over the last week at first session compared to final session (n = 12). Final session data are not present for participants who did not report intrusive memories at the final session (P4, P5, P7, P14).

Table 7 presents themes and verbatim responses extracted from participants' responses to open-ended questions about the impact of intrusive memories on their daily

functioning from the Retrospective Intrusive Memory measure (rated at first and final session). Clear improvements in daily functioning were reported by the majority of participants with some mixed impressions reported regarding work-related, behavioural and emotional impact. One participant reported ambiguous changes.

Table 7. Themes of subjective everyday functioning. Extracted from all participants' verbatim responses to the Retrospective Intrusive Memory measure question "*How have your intrusive memories affected your ability to function in your daily life in the past week*?" at first and final session (n = 12).

Themes of subjective everyday functioning at first session	Subthemes at first session	Participant reports at first session	Subthemes at final session	Participant reports at final session
Work-related impact	*Reluctance and worry about work.*	"I'm not wanting to go to work. I'm feeling anxious about going in to do the work that I love." "I'm reluctant to go into the hospital." "[Having intrusive memories] made me more apprehensive and worried about the next [medical] rotation." "I began rearranging clinical duties to avoid a trigger of the intrusive memories."	*Mixed impressions about work.*	"Going to work is still hard" "I was previously reluctant to go to the next medical rotation… when I have had memories about the event connected to the rotation, but now it's felt very much in my control. It couldn't have been a better timing to do the study." "I'm less stressed at work."
	Interference with the task at hand.	"It makes me stop my task at hand, usually at work: makes me stop for a minute… I have to gather myself and then get back to the work".	*Mixed impressions of changes in concentration / distractibility.*	"I can focus on the tasks at hand whilst at work". "…concentrating on certain things, e.g., doing a course, I'm still not able to carry on with it. However, things are a bit better at work – I'm able to concentrate on those tasks." "I feel less distracted – my mind is less 'whirring'. It's not jumping from

				thought to thought. I can just get on with work and I can stay on the point a lot more." "My concentration on driving is a lot better." "The intrusive memories aren't as vivid, they don't last as long, so I can focus on the tasks at hand whilst at work".
	Feeling unable to take up additional educational opportunities or career advancement (i.e., promotion).	"At work I'm meant to be starting another course and I cancelled it. I also turned down a promotion. I just don't feel able to take anything else on."	*Improvement in productivity.*	"When I need to do admin or teaching, report writing, I am more productive". "I'm more involved, picking back up and at speed with things."
	Delays in completing tasks at work and impact on productivity.	"If I have jobs to do, that's not usually disrupted. However, some procrastination can be present – I'm distracted by the memories and this delays the work I should be doing when I'm at work." "I'm doing things slower."	*Improvements in being able to switch off from work.*	"I feel like I'm now actually getting days off from work and there's more separation from work – it's more clean-cut when I'm home from work." "[The intervention] helping me to 'wind down' when coming home from a hard day at work."
	Unable to 'switch off' from work.	"[Having the intrusive memories] I feel like I've been working a full week when I've only been working a few days".		
Cognitive impact	*Difficulties with focused attention on*	"I find it difficult to focus on the road at times when passing the	*Cognitive 're-set'.*	"I have played [Tetris] twice since stopping the intrusive memory diary.

activities, for example driving, after experiencing an intrusive memory.	location where the event happened and [when the intrusive memory came into mind] I have run a red light on one occasion."		I find it's really helpful when I'm doing a lot of revision and it's a very good re-set. It's like a walk around the block but not having moved away from my laptop – I feel very fresh again".
Developing cognitive strategies to manage the intrusive memories, especially at work e.g., self-talk and emotional numbing: "I must continue, even though I'm feeling distressed".	"When working clinically and dealing with a patient, I don't want the thoughts of something else [memories] popping into my head. [So I] sweep them out of the way. This sometimes happens at home, but mostly at work." "I try to process them and decide they [intrusive memories] are not relevant – "I'm not going to deal with that right now"". "I'm getting used to them [but I'm] still carrying on even though I'm distressed by them."	*Greater internal locus of control and changes in appraisal of the event and associated intrusive memories.*	"It's not flashing back to me like it was. They aren't *intrusive* memories anymore. It used to take over, that's not happening anymore. Thoughts about the event are no longer bothersome – I'm feeling more "pragmatic" [about the traumatic event]: "yes it happened, and yes it was awful, but I got through it." It's not unmanageable and unbearable anymore." "I'm still getting some of the intrusive memories but they're a lot less bothersome, and I feel able to manage them better." "When I'm in a similar environment, I might still be triggered, but I don't find them bothersome anymore."
New ways of responding.	"Makes me make an emergency out of an urgency: I respond to the [intrusive] memory as a matter of emergency, so I don't respond the way I had done previously".		"I feel able to manage [the intrusive memories] better".

			Reduction in cognitive avoidance	"I feel like I'm coming at the experience at a different angle. I put it down to doing the intrusive memory diary, which was helpful because it gets you to engage with the experience. I would also put it down to Tetris. I just love Tetris. If I feel like I've had a bad and hard day at work, I just come home and play it to wind down. I played Tetris about four times in the last week. Tend to play it when I feel the need to wind down. Sometimes played it after thoughts of event."
Social and homelife impact	*Conversations with others.*	"I'm reluctant to talk about topics related to the intrusive memories". "I'm not taking notice of conversations I'm involved in."		
	Reduced sleep and increased fatigue.	"I feel tired because of lost sleep after the intrusive memory came into my mind." "I'm struggling to fall asleep." "I'm struggling to fall asleep and I'm waking up in the night and then struggling to go to sleep again." "Sometimes it [having intrusive memories] makes me very tired."	*Improvements in sleep.*	"I'm no longer struggling to get to sleep or waking up startled." "Sleep has been a bit better." "Previously I would struggle to get to sleep and would wake up startled and now it is nothing like that at all." "Sleep is still an issue, but it is getting better."

	Less sociable as once was before the intrusive memories.	"When I get them, I get tearful and I would then avoid people and take time to pull myself together." "I'm not wanting to be as social as I used to be." "Others have commented on me being quieter than my chatty self." "I'm less sociable at work."	*Re-engaging with others socially.*	"I've seen quite a few friends this week. I would have seen more friends but cannot because colleagues have contracted COVID." "I'm more conversive again with people, I'm more chatty with my colleagues."
	Struggling to carry out plans.	"It affects my motivation – I plan to do something and then I don't do it. Both at home or at work. Doing housework, seeing friends, exercising, going out of the house."	*Re-engaging with exercise.*	"I started running again over the last two weeks".
	Impact on relationship with partner.	"The memories can disrupt my relationship with my wife. If we are meant to be doing something nice, and if it's a stubborn memory, I might mention it, which can frustrate my wife because I'm bringing up work on my day off. My wife worries about me."	*Reduced tension within the family.*	"Frustration within the family about my mentioning intrusive memories I've been having… it's not happening anymore – I've not been needing to mention anything to my wife at all."
Emotional impact	*Heightened level of negative emotions and physiological responses.*	"When I get them, I get tearful." "Giving me palpitations of going into work."	*Reduced negative feelings and physiological responses, increase in positive feelings, mixed impressions of changes in distress.*	"At work I'm less stressed, less moody and happier."

	"One memory in particular makes me feel guilty." "It gets me thinking about the parents and I feel very sorry for the parents. I then feel sad afterwards." "It affects my mood, I'm feeling more anxious, more down than cheerful." "I have a heightened level of anxiety. I've learned to appreciate the little things."	"[a] manager noticed a difference – I was more myself now than at the beginning of the study" "I still feel a little distressed by [the intrusive memories]" "I still get the odd palpitation when going into work, but it's less." "I still get a bit sad thinking about the parents that couldn't have children." "I'm very pragmatic about it, and no longer distressed and low: "yes it happened, and yes it was awful, but I got through it."" "I'm feeling better in myself"
General improvements in functioning		"I don't feel like they [intrusive memories] are impacting me in any way now." "They've been affecting my functioning a lot lot less." "There's no impact on functioning anymore." "They [intrusive memories] haven't really popped up as much. Something popped up but hasn't really affected what I was doing."

	"It's just not a problem anymore. What helped is time passing, not going [that] job, being back at medical school, being in a different area, and the intervention." "The impact on daily life… it's not really a thing anymore."
Ambiguous changes	"I don't think I had intrusive memories as often as I thought I did. I don't think anything changed as such due to the study. It depends a lot on what I'm doing when I get them [the intrusive memories]. Things at home, or at work are the same." "Haven't been at work much this week so not having any intrusive memories might be connected to that too."

Secondary outcomes: Mental health symptoms

At the final session, only one participant (7%) met the cut-off indicating a probable diagnosis of PTSD, compared to nine out of fourteen participants (64%) at the first session. Only one participant (7%) met the cut-off for major depression diagnosis, compared to seven out of fourteen (50%) at first assessment. Two out of fourteen (14%) remained at the cut off criteria for GAD at final assessment, compared to five out of fourteen (36%) at first assessment. Apart from GAD-7 scores, there was a lack of stability in the baseline period in IES-R total, IES-R intrusion subscale and PHQ-9 scores (see Table 8). There were statistically significant changes from the first session to final session for all mental health outcomes as shown in Table 8. Graphs displaying week-by-week mental health outcomes for all participants can be found in Appendix 30.

Table 8. Ratings of mental health outcomes (n = 14).

	First session	Final session		Effect size	
	Mean (SD)	Mean (SD)	Analysis	*d*	95% CI for *d*
IES-R	40.86 (14.57)	12.43 (11.84)	Z = -3.30, p = .001		
IES-R Intrusion subscale	17.21 (5.81)	5.64 (4.33)	$t(13) = 8.63$, p <.001	2.31	1.27, 3.32
PHQ-9	9.71 (7.29)	3.71 (3.80)	$t(13) = 4.27$, p = .001	1.14	0.45, 1.81
GAD-7	7.93 (5.66)	3.50 (4.16)	Z = -3.05, p = .002		

Note: CI = confidence intervals.

Individual statistically reliable changes in mental health outcomes and sleep from baseline to post-intervention for all participants are shown in Table 9.

Table 9. Reliable Change Index from baseline to post-intervention (n = 14).

Participant	RCI					
	PSQI global score[9]	PSQI sleep quality[10]	IES-R[11]	IES-R intrusion subscale[12]	PHQ-9[13]	GAD-7[14]
P1	n/a	n/a	-42.72*	-15.67*	-4.90*	-1.89
P2	n/a	n/a	-60.99*	-11.26*	-9.29*	-0.60
P3	2.15*	0.00	-53.03*	-18.98*	-4.89*	-0.42
P4	-1.07	0.00	-94.58*	-34.43*	-2.44*	-0.63
P5			-159.10*	-46.35*	-11.74*	-2.64*
P6	5.37	0.00	-58.34*	-25.82*	0.49	0.75
P7	-4.30*	-3.80*	-106.07*	-28.47*	-2.44*	-1.13
P8	0.00	0.00	-19.45*	-10.59*	0.00	0.00
P9	-1.07	0.00	-45.08*	-13.90*	-0.49	-0.25
P10	-3.22*	-7.61*	-28.28*	-11.26*	-14.18*	-1.63
P11	-6.44*	-3.80*	-50.38*	-13.90*	-4.40*	-2.01*
P12	-2.15*	-3.80*	-98.11*	-21.19*	-16.63*	-4.40*
P13	1.07	0.00	-43.31*	-17.21*	-12.22*	-1.63
P14	-1.07	0.00	-20.33*	-12.58*	-1.47	0.25

Note: PSQI data was only collected for P3-P14 due to a later ethics amendment. PSQI scores for P5 are missing. Statistically reliable improvements are marked with an asterisk. CI = confidence intervals; GAD-7 = The Generalised Anxiety Disorder scale; IES-R = Impact of Events Scale–Revised; PHQ-9 = The Patient Health Questionnaire Depression scale; PSQI = The Pittsburgh Sleep Quality Index; RCI = reliable change index.

Tertiary outcome: Feasibility and acceptability of the intervention for NHS frontline staff

Participant feedback

All fourteen participants completed the feedback questionnaire at final session. Responses to Likert scale type questions are provided in Table 10, with open-ended question responses described below.

[9] An RCI of -1.13 was calculated based on a standard deviation of 1.70 and a test-retest correlation coefficient = 0.85 (Buysse et al., 1989), using the methodology proposed by (Jacobson & Truax, 1991).

[10] An RCI of -1.84 was calculated based on a standard deviation of 0.48 and a test-retest correlation coefficient = 0.85 (Buysse et al., 1989), using the methodology proposed by (Jacobson & Truax, 1991).

[11] An RCI of -100.51 was calculated based on a standard deviation of 1.00 and an internal consistency of Cronbach's alpha = 0.96 (Creamer, Bell, & Failla, 2003), using the methodology proposed by (Jacobson & Truax, 1991).

[12] An RCI of -30.65 was calculated based on a standard deviation of 1.09 and test-retest correlation coefficient = 0.94 (Creamer, Bell, & Failla, 2003), using the methodology proposed by (Jacobson & Truax, 1991).

[13] An RCI of -3.63 was calculated based on a standard deviation of 3.52 and a test-retest correlation coefficient = 0.89 (Kocalevent et al., 2013), using the methodology proposed by (Jacobson & Truax, 1991).

[14] An RCI of -2.23 was calculated based on a standard deviation of 3.41 and a test-retest correlation coefficient = 0.83 (Löwe et al., 2008), using the methodology proposed by (Jacobson & Truax, 1991).

Table 10. Participant feedback[15] means, standard deviations and ranges for responses on Likert scale type questions.

	Mean (SD)	Range
How easy did you find playing Tetris whilst at work? (0 = not at all easy, 10 = extremely easy) (*n* = 14)	4.57 (2.98)	0 – 9
How helpful did you find playing Tetris whilst at work?* (0 = not at all helpful, 10 = extremely helpful) (*n* = 12)	7.33 (2.35)	2 – 10
How burdensome did you find playing Tetris whilst at work?* (0 = not at all burdensome, 10 = extremely burdensome) (*n* = 12)	2.58 (2.43)	0 – 7
If you were experiencing intrusive memories in the future, how willing would you be to play Tetris if it was offered to you as something that would help? (0 = extremely unwilling, 10 = extremely willing) (*n* = 14)	8.93 (1.00)	8 – 10
If another staff member was having intrusive memories, how confident would you be in suggesting playing Tetris to them? (0 = extremely unconfident, 10 = extremely confident) (*n* = 14)	7.57 (1.65)	5 – 10
How easy did you find taking part in the study? (0 = not at all easy, 10 = extremely easy) (*n* = 14)	8.93 (1.21)	6 – 10
How burdensome did you find taking part in the study? (0 = not at all burdensome, 10 = extremely burdensome) (*n* = 14)	2.00 (1.88)	0 – 7

Note: two participants were not able to play Tetris whilst at work due to the limitations of their working environment (e.g., clinical duties, not having the time or space to do so), thus their responses to two questions in the Feedback questionnaire are not applicable (marked with an asterisk in the table).

[15] Questions were not phrased 'using the intervention', instead they refer solely to Tetris gameplay given that no reactivation of memories occurred for self-administered boosters at work, i.e., participants played Tetris immediately after an intrusive memory recurred at work.

To open-ended questions, participants gave positive feedback on the study as a whole and Tetris itself, and highlighted areas for improvement and learning points (comprehensive participant feedback is given in Appendix 31).

Participants generally found participating in the study easy, accessible and helpful: "*The study has been so fluid and easily accessible. Once people are in, they would stick with it because it's so easy and so good. It's just about getting people into the study*." A common theme amongst participants about playing Tetris was how attention grabbing and all-consuming it was: "*It takes your concentration somewhere else*.". Indeed, some participants have felt that the process of playing was a helpful 'distraction' after having an intrusive memory: "*[…] I play it from time to time following intrusive memories of other events in my life. It's a massive distraction*.". Several participants provided details on how they felt the intervention had impacted their intrusive memories: *"[…] The intrusive memories that were bothersome no longer feel bothersome. I think it was very effective for me."*; "*When I had the intrusive memory this week, it didn't have such a strong emotional potency and didn't have such a hold of me.*".

With regards to the feasibility of using the intervention whilst at work, participants commented on the low practicality due to lack of time: "*It's not practical to do Tetris at work – really hard to do it when on the road, especially to do the 25 minutes. There's no time for it at all. […] People might be more willing to re-activate their memory on their own […].*" For some participants, breaktimes were the only times they were able to access the game. However even then, some participants felt that it might not be easy to do so: "*Playing in the emergency department probably wasn't as helpful as it could have been. It did make a difference but not as much as if I was at home and playing it. […] During breaktimes is the*

only time that's possible [to play Tetris], *however even then, the staffroom is very busy and it's hard to concentrate*."

Some of the improvements to the study and to the game that participants suggested included: having Tetris on an app, having a version without advertisements, playing for fewer than 25 minutes and having regular reminders to play Tetris.

Participants also alluded to the potential challenges regarding the acceptability of the intervention within their respective hospital/pre-hospital departments: "*I didn't feel comfortable telling my nurse in charge that I need to go play Tetris*."; "*When colleagues describe intrusive memories, the expectation is that we sit there and listen. Culturally we are not there yet, to do something that might distract away from the memory. It might come across insensitive or that I'm not interested*.".

Rates of treatment adherence, outcome measure completion and attrition

Treatment adherence

Treatment adherence was 100%: all participants completed all three parts of the researcher-administered interventions according to the protocol i.e., successfully reactivated the memory, received mental rotation instructions and played Tetris for (at least) 25 minutes (see Appendix 32 for details about self-administered intervention boosters). The mean accuracy ratings for intrusive memory diary completion across all entries for all fourteen participants was 8.38 (*SD* = 1.24), with values ranging from zero to ten.

Outcome measure completion

The primary outcome completion rate was 98.9% (358/362 completed days of the intrusive memory diary). Two days of intrusive memory diary data were missing for P1 and two days for P2 (n = 4/362; 0.6%). There was no further intrusive memory diary data missing.

With regards to secondary data, the IES-R, PHQ-9 and GAD-7 completion rate was 98.9%, given week five IES-R, PHQ-9 and GAD-7 were missing for one participant (n = 1/88; 1.1%). The PSQI completion rate was 95.8% as a follow-up PSQI was missing for one participant (n = 1/24; 4.2%).

Attrition

All participants remained in the study for its entirety (P1 for 42 days, P2 for 56 days, and 22 days for the remaining participants).

Duration of Tetris gameplay

All participants played Tetris for a minimum of 25 minutes during researcher-administered intervention sessions (M = 25.14 minutes, SD = 0.45, *range* = 25 – 27 minutes).

Intervention compliance

All participants except one[16] showed an increase from pre- to post-memory reminder procedure, and then a decrease to post-Tetris gameplay, indicating successful memory reactivation using the memory reminder procedure. The mean within-intervention session measures of arousal increased from 2.70 (SD = 1.73) at the pre-memory reminder stage to 6.04 (SD = 1.34) immediately following the memory reminder procedure. This change was statistically significant, Z = -4.49, p <.001. The arousal consequently decreased to a mean rating of 2.33 (SD = 1.52) following Tetris gameplay, representing a statistically significant change, Z = -4.58, p <.001. At the final session, P13 reported that when he had played Tetris at work immediately following an intrusive memory, there were occasions where it was not possible to play for longer than 5 to 10 minutes at a time.

[16] The pre-memory reminder arousal rating was a 9 and it remained a 9 at post-memory reminder.

Discussion

Summary of findings

This case series is the first test of the capacity of a simple cognitive intervention to reduce intrusive memories in frontline NHS healthcare staff exposed to traumatic events at work. We evaluated the effect of the intervention on the number of intrusive memories, functioning and mental health symptoms, as well as the feasibility of delivering the intervention and its acceptability for this group. Overall, using an omnibus analysis of the series, the intervention was found to significantly reduce the number of intrusive memories from baseline to post-intervention with a small effect size. Across participants, there was a decrease (60%) in the mean number of intrusive memories per day from the baseline period to the post-intervention period. Individual AB comparisons found that the intervention significantly reduced the number of intrusive memories with small effect sizes for one participant and with medium effect sizes for three participants. Participants reported changes in key intrusion characteristics, e.g., a 47% reduction in intrusion-related distress and a 41% reduction in vividness from first to final session and described changes in the way in which they appraised their intrusive memories. For example, following the intervention, participants rated their intrusive memories as less 'bothersome', and had a better internal locus of control regarding their ability to manage intrusions when they did come to mind. A shift in appraisals was also evident in participants' qualitative responses: even when intrusions were still present, participants generally indicated that they were no longer as bothersome, unmanageable or unbearable. A notable outcome was the functional improvement that participants reported. There was a 72% reduction in how much intrusive memories interfered with daily functioning. Qualitatively, participants reported improvements in cognitive, behavioural and emotional functioning within social, home life and work-related domains, which were at baseline perceived as negatively impacted by the experience of intrusive

memories. Sleep (global PSQI) scores overall did not yield a statistically significant change from first to final session. Five participants, however, experienced significantly reliable improvements in their sleep. Significant reductions in mental health symptoms were observed. Specifically, there was a 66% reduction in post-traumatic stress symptoms, a 58% reduction in depression symptom scores and a 53% reduction in anxiety symptom scores. Statistically reliable reductions were seen among all participants' post-traumatic stress symptoms, ten participants' depression symptoms, and three participants' anxiety symptoms. Participants generally found participating in the study easy, accessible and helpful, but found playing Tetris for 25 minutes *at work* difficult. Treatment adherence was excellent (100%), with all participants adhering to protocol for all three parts of the researcher-administered interventions. Outcome measure completion rate was high (primary and secondary outcome mean: 97.9%). There was no drop-out from the study. No adverse consequences of the intervention procedure or other study procedures were reported.

Interpretation of findings

The current study provides further evidence of the effectiveness of the intervention in reducing intrusive memories in trauma-exposed samples (e.g., inpatients with complex PTSD (Kessler et al., 2018); refugees (Kanstrup et al., 2020)), and extends this to healthcare workers. There was a significant overall small omnibus effect size across the fourteen participants in the study, and all participants showed a mean percentage reduction in intrusive memories from baseline to post-intervention. One participant (P13) showed a comparatively low mean percentage reduction (10%). On further exploration of this inconsistency, it became apparent that P13 did not adhere to the protocol on the self-administered booster sessions. They were unable to play Tetris for the full 25 minutes at work and only played for approximately 10 minutes after having an intrusive memory, as this was all the time they had available. It is possible that the interruption to this intervention component resulted in a

smaller intervention effect. This highlights the crucial importance of future research to investigate the minimum effective length of the intervention.

To our knowledge, this was the first time that the effectiveness of this intervention was analysed within an AB single-case experimental design using Tau-*U* methodology. Thus, direct comparability of the findings from the Tau-*U* analysis in this study across other studies examining the effectiveness of this intervention was not possible. For example, Kessler et al., (2018), used a within-subjects multiple baseline AB design (Barlow et al., 2008) where comparisons were made between intrusive memories which were specifically targeted with the intervention and those that we not ('non-targeted'). Whilst this study does not allow for inferences to be made about the specificity of interventional targeting as analyses are not carried out at individual intrusion level, Tau- *U* analysis allows for controlling for a baseline trend, where trend in the baseline is an inferential problem often encountered in single-case experiments (Kratochwill et al., 2010). A notable result of the Tau-*U* analysis was that thirteen out of fourteen participants did not require a baseline trend correction. 'Stable' baseline data allows for more confidence in attributing a change in the trend of scores to the intervention rather than pre-existing baseline trends (Brossart et al., 2018). Whether certain intrusive memories may be thematically linked, such that delivering the intervention for one intrusive memory may have reduced the number of others that were associated in some way during the post-intervention period, is beyond the scope of this study and is an interesting avenue for further exploration. Interestingly, some participants reported a series of different intrusions in quick succession, where one 'main' intrusion appeared to 'set off' consequent intrusions. Due to data on themes among intrusive memories not being available in Kessler and colleagues (2018), it is unclear whether that study detected similar themes among intrusions.

Aspects of intrusive memory characteristics being positively augmented during the study period was also supported by reductions observed in intrusive memory vividness with medium effect size (Kanstrup et al., 2021). Further, bothersome daily intrusive memories disrupting concentration at baseline was consistent with Holmes and colleagues (2017) who found that for the majority of their participants (68%), intrusions disrupted concentration for longer than five minutes. Moreover, reduced psychopathology symptoms (e.g., PTSD) and improved functioning is in accordance with evidence that intrusive symptoms are centrally linked to other PTSD symptoms (Bryant et al., 2017). Thus, the goal of further research investigating the helpfulness of this intervention among clinical staff should not solely focus on the reduction in the number of intrusive memories, but more importantly, the change in functional and mental health outcomes.

Intervention manipulation checks were a crucial component of this study design. Specifically, they facilitated the checking of potential immediate effects of the intervention and gave insight as to whether the memory reminder procedure had reactivated the trauma memory sufficiently to make the consolidated memory labile for reconsolidation. Within-intervention arousal ratings indicated that the intervention components had the expected effect in this sample. Self-reported arousal ratings showed a pattern of increase after the memory reminder procedure, indicating that the manipulation had the desired effect of reactivating the memory. Conversely, the decrease in arousal ratings after playing Tetris, which was below the baseline arousal rating for 48% of researcher-administered sessions, suggests a likely calming effect of playing Tetris. This is consistent with Kessler and colleague's finding (2018) regarding arousal changes during the intervention procedure. Further studies examining the mechanisms of memory consolidation can hopefully shed light on how much reactivation is 'just right', i.e., enough to begin the process of memory updating but not too distressing so that it overwhelms one's resources or tips into exposure

(as in exposure therapy: Foa (2011)). This will help to refine the necessary conditions to optimise the intervention effect.

In this study participants only had the option to play Tetris on their own, without researcher support, immediately after they had an intrusive memory, thus, they were not asked to reactivate the memory themselves unless it occurred spontaneously. Thirty-nine percent of all intrusive memories were experienced by participants whilst they were at work. On the participant feedback questionnaire, participants indicated that it was very difficult for them to use the intervention after experiencing intrusions at work due to lack of time within busy work demands. Further, studies examining the feasibility of self-reactivating established memories to allow for a fully automated administration of the intervention are needed.

This research study was carried out in the context of the COVID-19 pandemic. Some of our participants represent a staff group who are among the most vulnerable to moral distress and burnout symptoms of medical professionals (Kok et al., 2021). Further, the intrusive memories that staff were experiencing occurred during a time of heightened anxiety, uncertainty and longer hours spent working in a stressful environment, likely increasing the potential for the intrusive memories to be re-triggered (Schultebraucks et al., 2019). Changes to participants' emotional wellbeing and how this may have influenced the likelihood of them being recruited into the study, as well as their level of engagement with the intervention, are unknown. Given the changes in societal functioning during the COVID-19 pandemic, e.g., national lockdowns restricting face-to-face interactions, a number of modifications to the design and procedure were needed to be implemented after the study had commenced. First, the study duration was reduced, and thus varied across participants. Second, whilst psychological symptoms were formally assessed, the direct impact of the pandemic on participants was not (see 33 for an informal assessment of COVID-19 impact on participants). Within this context study procedures were adapted for remote (rather than in-

person) delivery. As a result, the intervention was delivered in person for the first participant only, and for subsequent participants Tetris was accessed online, with minor differences (e.g., 15 second advertisements occasionally presented either immediately before starting Tetris or after the 'game over' screen appeared). Whilst such modifications resulted in some inconsistency between participants, we note that minor between-participant adaptations to an intervention are inherent to and in accordance with the objectives of a case series approach. Further, that we delivered the intervention according to the protocol and demonstrated its efficacy despite these modifications speaks to both its flexibility and potential for remote delivery – two key features of a scalable intervention.

Limitations and further research

We acknowledge some important aspects of the study that should be considered when interpreting its findings. First, the limitations which are inherent to the Tau-*U* (Parker et al., 2011) methodology. It is not possible, for example, to represent the correction for baseline trend used in Tau-*U*, which was utilised for P2 in this study, on a visual graph (Tarlow, 2017). Given that visual analysis is an integral part of case series analysis (Brossart et al., 2006), this eliminates the opportunity for interpretation of the 'baseline corrected' results on a time-series graphs. Second, a limitation of this study is that it was not pre-registered on a publicly available registry. Pre-registration is important as it provides a time-stamped record of decisions made at the conception stage and communicates principles of openness and transparency (Stewart et al., 2020). Research which is not pre-registered is susceptible to increased biases such as selective reporting of outcomes or statistical analyses (Stewart et al., 2020), citation (Bastiaansen et al., 2015) or hindsight bias (Nosek, et al., 2017). Thus, not pre-registering this study makes it more vulnerable to such biases. Third, a major limitation of this study is the lack of a control group given a case series design. Future research may consider comparing the brief behavioural task intervention with a control intervention e.g.,

one that does not rely on theories of memory consolidation/reconsolidation nor 'dual task' interference, under controlled conditions. Fourth, the sample was predominantly comprised of white female participants, and nurses at NHS banding 5 to 6. Future studies should evaluate the intervention in samples that are more representative of the typical population of hospital and pre-hospital NHS staff. Fifth, we employed an AB single-case experimental design methodology. Studies in which researchers examine individual factors associated with intervention efficacy and test the effectiveness and feasibility of this intervention using randomisation procedures will be important next steps in its evaluation. Sixth, despite the intrusive memory diary having been utilised in other clinical studies (e.g., Holmes et al., 2017; Iyadurai et al., 2018; Kanstrup et al., 2021), neither this measure nor the Retrospective Intrusive Memory measure are validated. Studies evaluating the validity and reliability of these outcome measures are needed. Seventh, future studies may benefit from adding additional controls for time: for example, the length of time participants have experienced intrusive memories for since the traumatic event, the stability of daily intrusive memories over time, and the extent to which the week prior to enrolment in the study is 'typical' for each participant in terms of the number of intrusive memories experienced. Finally, although this study looked at intrusive memories linked to occupational events, there is no indication that this intervention could not be applied to personal memories or those which are not work-related (as in other studies, e.g., Kanstrup et al., 2020).

Conclusion

In conclusion, this case series of frontline NHS clinical staff provides encouraging evidence for the efficacy of a simple cognitive intervention to reduce the number of intrusive memories and improve mental health and functioning. Important next steps will be to

optimise the intervention for digital delivery and test its effectiveness with healthcare staff using a randomised controlled design. Such future trials will enable progression towards a remotely delivered, scalable intervention to mitigate the effects of traumatic events, including during the COVID-19 pandemic, on healthcare staff globally.

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Appendix 1: Journal instruction for authors: European Journal of Psychotraumatology

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Updated 08-06-2020

Appendix 2: Full electronic search strategy

Database	Type	Search number	Search Terms	Results
PsycINFO	Key word	1	("Intrusive Memor*" OR "Involuntary Memor*" OR "Intrusive Recollection*" OR "Involuntary Recollection*").ti,ab	759
	Thesaurus	2	"INTRUSIVE THOUGHTS"/	873
	Key word	3	(Trauma OR PTSD OR "Post Traumatic Stress Disorder" OR "Post-traumatic stress disorder" OR Traumat* OR Distress OR "posttraumatic stress disorder").ti,ab	181,949
	Thesaurus	4	"POSTTRAUMATIC STRESS DISORDER"/ OR "COMPLEX PTSD"/ OR "TRAUMATIC NEUROSIS"/ OR "EMOTIONAL TRAUMA"/ OR TRAUMA/ OR DESNOS/ OR "POST-TRAUMATIC STRESS"/ OR "COMBAT	71,763

			EXPERIENCE"/ OR "ACUTE STRESS DISORDER"/	
	Combine		*(1 OR 2) AND (3 OR 4)* [Peer reviewed] [Languages English]	438
Medline	Key word	5	("Intrusive Memor*" OR "Involuntary Memor*" OR "Intrusive Recollection*" OR "Involuntary Recollection*").ti,ab	516
	Keyword	6	(Trauma OR PTSD OR "posttraumatic stress disorder" OR "Post Traumatic Stress Disorder" OR "Post-traumatic stress disorder" OR Traumat* OR Distress).ti,ab	492,753
	Thesaurus	7	exp "STRESS DISORDERS, TRAUMATIC"/ OR exp "STRESS DISORDERS, POST-TRAUMATIC"/ OR "WAR-RELATED INJURIES"/ OR "PSYCHOLOGICAL TRAUMA"/ OR "COMBAT DISORDERS"/ OR exp	73,788

			"ADULT SURVIVORS OF CHILD ADVERSE EVENTS"/ OR exp "PSYCHOLOGICAL DISTRESS"/	
	Combine		*5 AND (6 OR 7)* [Peer reviewed] [Languages English]	146
PubMed	Key word	8	("Intrusive Memor*" OR "Involuntary Memor*" OR "Intrusive Recollection*" OR "Involuntary Recollection*").ti,ab	1,376
	Key word	9	(Trauma OR PTSD OR "posttraumatic stress disorder" OR "Post Traumatic Stress Disorder" OR "Post-traumatic stress disorder" OR Traumat* OR Distress).ti,ab	1,474,353
	Combine		*8 AND 9*	629

Appendix 3: Bespoke screening and selection tool

"How are intrusive memories of trauma associated with functioning?"

HDAS identifier number:

Patient population	
Include: ☐ Adults aged 18+ ☐ Adults experiencing trauma related intrusive memories	Exclude: ☐ Participants aged <18 ☐ Adults who are experiencing intrusive memories that are not trauma-related, e.g., intrusive memories in depression
Language	
Include: ☐ English language	Exclude: ☐ Any other language that is not English
Exposure & Outcomes	
Include: ☐ Measure of intrusive memories ☐ Measure of functioning falls within the domains of the ICF	Exclude: ☐ Studies that measure intrusive thoughts alone ☐ Where intrusive memories are measured as part of the re-experiencing PTSD cluster
Study design	
Include: ☐ Quantitative study (can include, interventional studies, RCT, cross-sectional, cohort, case-control, case series)	Exclude: ☐ Qualitative study ☐ Case study or case report
Methodology	
Include: ☐ Studies where intrusive memories and functioning are measured at the same timepoint or where intrusive memories are measured at T1 and functioning at T2 (or beyond)	Exclude: ☐ Studies where there is a direct predictive relationship between functioning outcomes (y) and intrusive memories (x), i.e., y → x. Specifically, studies where the analysis or design are such that functioning is measured at T1 and intrusive memories at T2 (or beyond)
Decision Making	
☐ All criteria met - include for full-text screening ☐ Exclude study ☐ Unsure - full-text screening is required	
Comments	

Appendix 4: ICF Beginners Guide: Towards a Common Language for Functioning, Disability and Health (WHO, 2002)

Towards

a

Common Language

for

Functioning, Disability and Health

ICF

WHO/EIP/GPE/CAS/01.3 Original: English Distr.: General

World Health Organization Geneva

2002

Towards a

Common Language

for

Functioning, Disability and Health:

ICF

The International Classification
of Functioning, Disability and Health

Introduction 2 ICF and the WHO Family of Classifications 3 The need for ICF 4 How will WHO use ICE 5 How can ICF be used? 6

The Model of ICF 9 Concepts of functioning and disability 10

The qualifiers
Underlying principles of ICF

The Domains of ICF Conclusion
The World-Wide ICF Network

11 14

15 19 20

INTRODUCTION

The International Classification of Functioning, Disability and Health, known more commonly as ICF, provides a standard language and framework for the description of health and health-related states. Like the first version published by the World Health Organization for trial purposes in 1980, ICF is a multi- purpose classification intended for a wide range of uses in different sectors. It is a classification of health and health-related domains -- domains that help us to describe changes in body function and structure, what a person with a health condition can do in a standard environment (their level of capacity), as well as what they actually do in their usual environment (their level of performance). These domains are classified from body, individual and societal perspectives by means of two lists: a list of body functions and structure, and a list of domains of activity and participation. In ICF, the term functioning refers to all body functions, activities and participation, while disability is similarly an umbrella term for impairments, activity limitations and participation restrictions. ICF also lists environmental factors that interact with all these components.

ICF is WHO's framework for health and disability. It is the conceptual basis for

the definition, measurement and policy formulations for health and disability. It is a universal classification of disability and health for use in health and health- related sectors. ICF therefore looks like a simple health classification, but it can be used for a number of purposes. The most important is as a planning and policy tool for decision-makers.

ICF is named as it is because of its stress is on health and functioning , rather than on disability. Previously, disability began where health ended; once you were disabled, you where in a separate category. We want to get away from this kind of thinking. We want to make ICF a tool for measuring functioning in society, no matter what the reason for one's impairments. So it becomes a much more versatile tool with a much broader area of use than a traditional classification of health and disability.

This is a radical shift. From emphasizing people's disabilities, we now focus on their level of health.

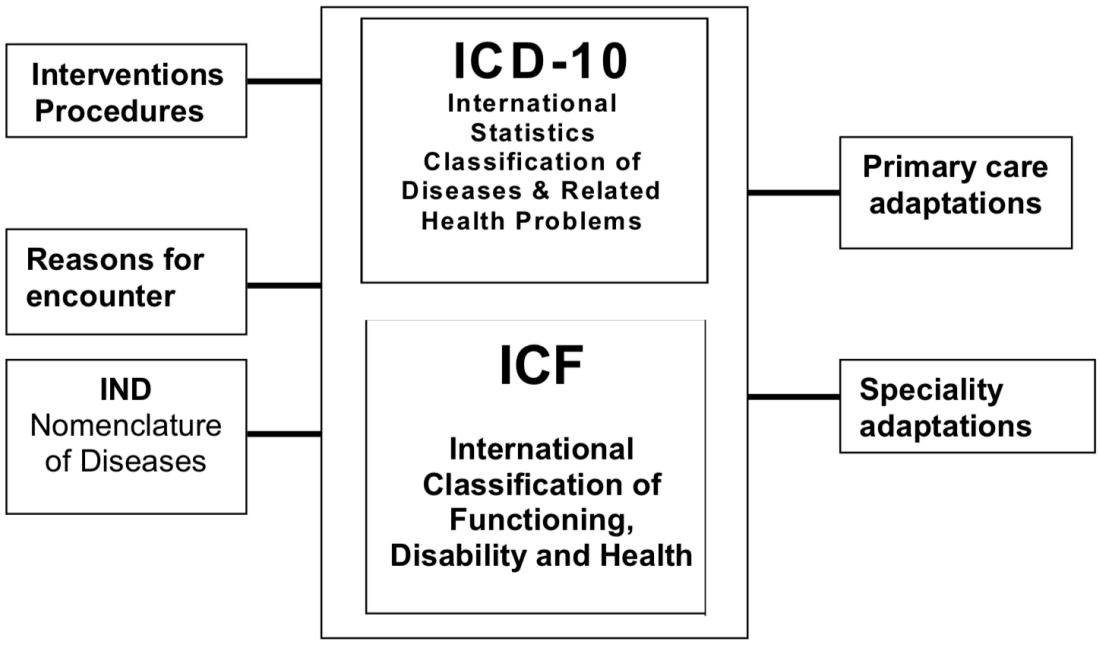
ICF puts the notions of ‘health’ and ‘disability’ in a new light. It acknowledges that every human being can experience a decrement in health and thereby experience some disability. This is not something that happens to only a minority of humanity. ICF thus ‘mainstreams’ the experience of disability and recognises it as a universal human experience. By shifting the focus from cause to impact it places all health conditions on an equal footing allowing them to be compared using a common metric – the ruler of health and disability.

THE WHO FAMILY OF INTERNATIONAL CLASSIFICATIONS

ICF belongs to the WHO family of international classifications, the best known member of which is the ICD-10 (the International Statistical Classification of Diseases and Related Health Problems). ICD-10 gives users an etiological framework for the classification, by diagnosis, of diseases, disorders and other health conditions. By contrast, ICF classifies functioning and disability associated with health conditions. The ICD-10 and ICF are therefore complementary, and users are encouraged to use them together to create a broader and more meaningful picture of the experience of health of individuals and populations. Information on mortality (provided by ICD-10) and information about health and health-related outcomes (provided by ICF) can be combined in summary measures of population health.

In short, ICD-10 is mainly used to classify causes of death, but ICF classifies health.

WHO Family of International Classifications



THE NEED FOR ICF

Studies show that diagnosis alone does not predict service needs, length of hospitalization, level of care or functional outcomes. Nor is the presence of a disease or disorder an accurate predictor of receipt of disability benefits, work performance, return to work potential, or likelihood of social integration. This means that if we use a medical classification of diagnoses alone we will not have the information we need for health planning and management purposes. What we lack is data about levels of functioning and disability. ICF makes it possible to collect those vital data in a consistent and internationally comparable manner.

For basic public health purposes, including the determine the overall health of populations, the prevalence and incidence of non-fatal health outcomes, and to measure health care needs and the performance and effectiveness of health care systems, we need reliable and comparable data on the health of individuals and populations. ICF provides the framework and classification system for these purposes.

For some time, there has been a shift in the focus from hospital-based acute care to community-based long-term services for chronic conditions. Social welfare agencies have noticed a marked increased in demand for disability benefits. These trends have underscored the need for reliable and valid disability statistics. ICF provides the basis for identifying kinds and levels of disability which provides the foundations for country-level disability data to inform policy development.

There is also an increased recognition among social planners and service agencies that reductions in the incidence and severity of disability in a population can be brought about both by enhancing the functional capacity of the person and by improving performance by modifying features of the social and physical environment. To analyze the impact of these different interventions, we need a way of classifying domains of areas of life as well as the environmental factors that improve performance. ICF allows us to record this information.

HOW WILL WHO USE ICF?

WHO must provide tools that our Member States can use to improve their health policies, achieve better health for their population and to ensure that their health systems are as cost effective and fair as possible. We provide tools that are based on the best science and which represent the basic core values on which the Organization bases its work: equity, inclusion and the aim of all to achieve a life where each person can exploit his or her opportunities to the fullest possible degree.

Last year, the 191 Member States of the World Health Organization agreed to adopt ICF as the basis for the scientific standardization of data on health and disability world-wide. ICF directly contributes to WHO's efforts to establish a comprehensive population health measurement framework. We would like to go beyond the old, traditional mortality and morbidity measures by including measures of functional domains of health.

WHO uses a multi-dimensional health measure as the basis for health systems performance assessment. The health goal of a health system is measured on the basis of ICF. In this way, WHO can assist Member States in enhancing the performance of their health systems. With

better functioning health systems, health levels across the population are raised and everyone benefits.

The ICF is key example of such a tool. ICF is a scientific tool for consistent, internationally comparable information about the experience of health and disability. As such, it also provides the basis for WHO overall approach to health.

HOW CAN ICF BE USED?

Because of its flexible framework, the detail and completeness of its classifications and the fact that each domain is operationally defined, with inclusions and exclusions, it is expected that ICF, like its predecessor, will be used for a myriad of uses to answer a wide range of questions involving clinical, research and policy development issues. (For specific examples of the uses of ICF in the area of service provision, and the kinds of practical issues that can be addressed, see the box below.)

ICF Applications
Service Provision

At the individual level

- For the assessment of individuals: *What is the person's level of functioning?*
- For individual treatment planning: *What treatments or interventions can maximize functioning*?
- For the evaluation of treatment and other interventions: *What are the outcomes of the treatment? How useful were the interventions?*
- For communication among physicans, nurses, physiotherapists, occupational therapists and other health works, social service works and commmunity agencies
- For self-evaluation by consumers*: How would I rate my capacity in mobility or communication?*

At the institutional level…

- For educational and training purposes
- For resource planning and development: *What health care and other services will be needed?*
- For quality improvement: *How well do we serve our clients? What basic indicators for quality assurance are valid and reliable?*
- For management and outcome evaluation: *How useful are the services we are providing?*
- For managed care models of health care delivery: *How cost-effective are the services we provide? How can the service be improved for better outcomes at a lower cost?*

At the social level…

- For eligibility criteria for state entitlements such as social security benefits, disability pensions, workers' compensation and insurance: *Are the criteria for eligibility for disability benefits evidence based, appropriate to social goals and justifiable*?
- For social policy development, including legislative reviews, model legislation, regulations and guidelines, and definitions for anti-discrimination legislation: *Will guaranteeing rights improve functioning at the societal level? Can we measure this improvement and adjust our policy and law accordingly?*
- For needs assessments: *What are the needs of persons with various levels of disability - impairments, activity limitations and participation restrictions?*
- For environmental assessment for universal design, implementation of mandated accessibility, identification of environmental facilitators and barriers, and changes to social policy: *How can we make the social and built environment more accessible for all person, those with and those without disabilities*? *Can we assess and measure improvement?*

Among the other kinds of uses for ICF are these:

Policy development...

In both the health sectors and other sectors that need to take into account the functional status of people, such as social security, employment, education and transportation, there is an important role that ICF can play. It goes without saying that policy development in these sectors requires valid and reliable population data on functional status. Legislative and regulatory definitions of disability need to be consistent and grounded in a single coherent model of the disability creation process. Whether it is devising eligibility criteria for disability pensions, developing regulations for access to assistive technology, or mandating housing or transportation policy that accommodates individuals with mobility, sensory or intellectual disability, ICF can provide the framework for comprehensive and coherent disability-related social policy.

Economic analyses...

Most applications of ICF lend themselves to economic analyses. Determining whether resources are effectively used in health care and other social services requires a consistent and standard classification of health and health-related outcomes that can be costed and compared internationally. We need information on the disability burden of various diseases and health conditions. To ensure that society can effectively prevent limitations on activities and restrictions on participation, it needs to cost the economic impact of functional limitations as compared to the costs of modifying the built and social environment. ICF makes both of these tasks possible.

Research uses...

Generally, ICF assists in scientific research by providing a framework or structure for interdisciplinary research in disability and for making results of research comparable. Traditionally, scientists have measured the outcomes of health conditions by relying on mortality data. More recently, the international concern about health care outcomes has shifted to the assessment of functioning at the level of the whole human being, in day-to-day life. The need here is for universally applicable classification and assessment tools, both for activity levels and overall levels of participation, in basic areas and roles of social life. This is what ICF provides and makes possible.

Intervention studies...

Of particular interest in research are intervention studies that compare the outcomes of interventions on similar populations. ICF can facilitate this kind of research by clearly distinguishing interventions – and coding outcomes – in light of the aspect of disability that the intervention addresses. Body level or impairment interventions are primarily medical or rehabilitative, and attempt to prevent or ameliorate limitations in person or societal level functioning by correcting or modifying intrinsic functions or structures of the body. Other rehabilitative treatment strategies and interventions are designed to increase capacity levels. Interventions that focus on the actual performance context of an individual may address either capacity-improvement or else seek environmental modification, either by eliminating environmental barriers or creating environmental facilitators for expanded performance of actions and tasks in daily living.

Uses of Environment Factors...

One of the major innovations in ICF is the presence of an environmental factor classification that makes it possible for the identification of environmental barriers and facilitators for both capacity and performance of actions and tasks in daily living. With this classification scheme, which can be used either on an individual basis or for population wide data collection, it may be possible to create instruments that assess environments in terms of their level of facilitation or barrier-creation for different kinds and levels of disability. With this information in hand, it will then be more practical to develop and implement guidelines for universal design and other environmental regulations that extend the functioning levels of persons with disabilities across the range of life activities.

THE MODEL OF ICF

Two major conceptual models of disability have been proposed. The medical model views disability as a feature of the person, directly caused by disease, trauma or other health condition, which requires medical care provided in the form of individual treatment by professionals. Disability, on this model, calls for medical or other treatment or intervention, to 'correct' the problem with the individual.

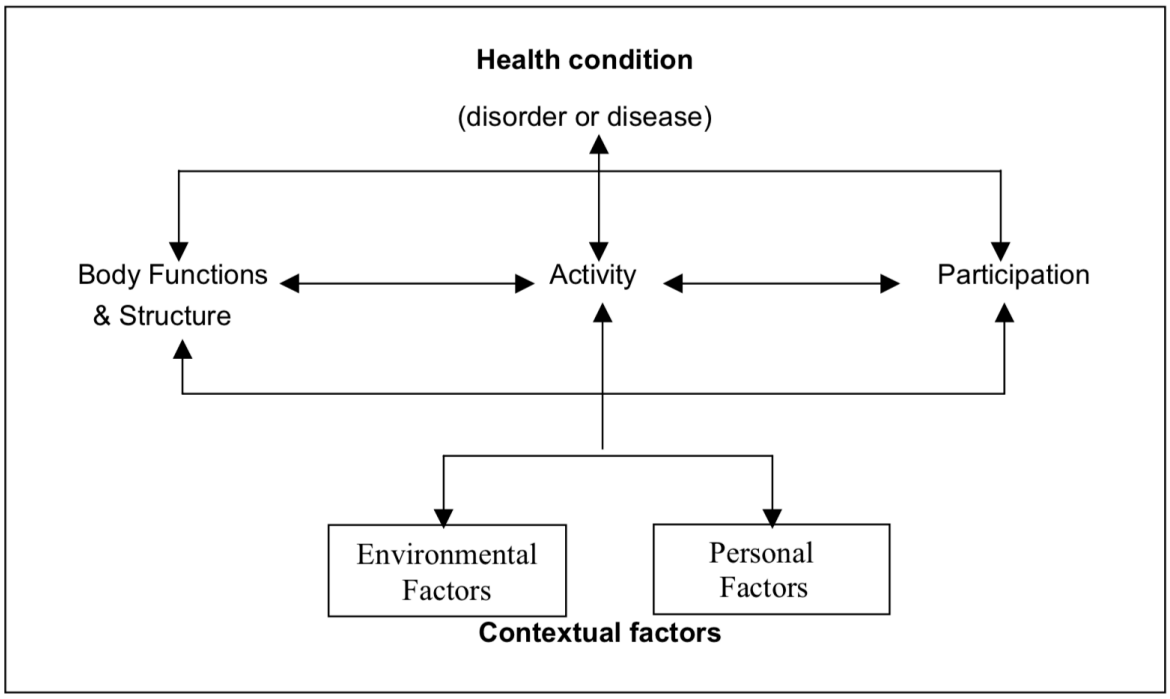
The social model of disability, on the other hand, sees disability as a socially- created problem and not at all an attribute of an individual. On the social model, disability demands a political response, since the problem is created by an unaccommodating physical environment brought about by attitudes and other features of the social environment.

On their own, neither model is adequate, although both are partially valid. Disability is a complex phenomena that is both a problem at the level of a person's body, and a complex and primarily social phenomena. Disability is always an interaction between features of the person and features of the overall context in which the person lives, but some aspects of disability are almost entirely internal to the person, while another aspect is almost entirely external. In other words, both medical and social responses are appropriate to the problems associated with disability; we cannot wholly reject either kind of intervention.

A better model of disability, in short, is one that synthesizes what is true in the medical and social models, without making the mistake each makes in reducing the whole, complex notion of disability to one of its aspects.

This more useful model of disability might be called the biopsychosocial model. ICF is based on this model, an integration of medical and social. ICF provides, by this synthesis, a coherent view of different perspectives of health: biological, individual and social.

The following diagram is one representation of the model of disability that is the basis for ICF



Concepts of functioning and disability

As the diagram indicates, in ICF disability and functioning are viewed as outcomes of interactions between health conditions (diseases, disorders and injuries) and contextual factors.

Among contextual factors are external environmental factors (for example, social attitudes, architectural characteristics, legal and social structures, as well as climate, terrain and so forth); and internal personal factors, which include gender, age, coping styles, social background, education, profession, past and current experience, overall behaviour pattern, character and other factors that influence how disability is experienced by the individual.

The diagram identifies the three levels of human functioning classified by ICF: functioning at the level of body or body part, the whole person, and the whole person in a social context. Disability therefore involves dysfunctioning at one or more of these same levels: impairments, activity limitations and participation restrictions. The formal definitions of these components of ICF are provided in the box below.

Body Functions are physiological functions of body systems (including psychological functions).

Body Structures are anatomical parts of the body such as organs, limbs and their components.

Impairments are problems in body function or structure such as a significant deviation or loss.

Activity is the execution of a task or action by an individual.

Participation is involvement in a life situation.

Activity Limitations are difficulties an individual may have in executing activities.

Participation Restrictions are problems an individual may experience in involvement in life situations.

Environmental Factors make up the physical, socal and attitudinal environment in which people live and conduct their lives..

The Qualifiers

The list of domains in ICF becomes a classification when qualifiers are used. Qualifiers record the presence and severity of a problem in functioning at the body, person and societal levels.

For the classifications of body function and structure, the primary qualifier indicates the presence of an impairment and, on a five point scale, the degree of the impairment of function or structure (no impairment, mild, moderate, severe and complete).

In the case of the Activity and Participation list of domains, two important qualifiers are provided. Together, these qualifiers enable the user to code essential information about disability and health.

The Performance qualifier describes what an individual does in his or her current environment. Since the current environment always includes the overall societal context, performance can also be understood as "involvement in a life situation" or "the lived experience" of people in their actual context. (The 'current environment' will be understood to include assistive devices or personal assistance, whenever the individual actually uses them to perform actions or tasks.)

The Capacity qualifier describes an individual’s ability to execute a task or an action. This construct indicates the highest probable level of functioning of a person in a given domain at a given moment.

When a person has a capacity problem associated with a health condition, therefore, that incapacity is a part of their state of health. To assess the full ability of the individual, one

would need to have a “standardized environment" to neutralize the varying impact of different environments on the ability of the individual. In practice, there are many possible environments that we could use for this purpose.

That is, a standardized environment might be: (a) an actual environment commonly used for capacity assessment in test settings; or (b) an assumed environment thought to have an uniform impact; or (c) an environment with precisely defined parameters based on extensive scientific research. Whatever it is in practice, this environment can be called 'uniform' or 'standard' environment. The capacity construct therefore reflects the environmentally-adjusted ability of the individual in a specified domain. The Capacity qualifer assumes a 'naked person' assessment, that is, the person's capacity without personal assistance or the use of assistive devices. For assessment purposes, this environmental adjustment has to be the same for all persons in all countries to allow for international comparisons. For precision and international comparability, features of the uniform or standard environment can be coded using the Environmental Factors classification.

For a disability and health classification it is important that users be able to express these domains by means both of a performance and a capacity construct, even if, in particular cases for special uses only one of the two constructs are employed. ICF provides a single list of Activities and Participation which users can, for their needs and purposes, employ either by

A) designating some domains as Activities and others as Participation and not allowing overlap;

B) making this designation but allowing overlap in particular cases;

C) designating detailed (third- or fourth-level) cateogries within a domain as Activities and broad (second-level) categories in the domain as Participation;

D) designating all domains as potentially both Activity and Participation, and employing the qualifiers to distinguish the information that is required and collected.

(The approach described in D) is WHO's default approach and ICF country data submitted to WHO will be assumed to reflect this approach.)

Having access to both performance and capacity data enables ICF user to determine the 'gap' between capacity and performance. If capacity is less than performance, then the person's current environment has enabled him or her to perform better than what data about capacity would predict: the environment has facilitated performance. On the other hand, if capacity is greater than performance, then some aspect of the environment is a barrier to performance.

The distinction between environmental ‘barriers’ and ‘facilitators’, as well as the extent to which a environmental factor acts in one way or another, is captured by the qualifier for coding Environmental Factors.
Finally, an additional qualifier is available to supplement this information. Both the Capacity and Performance qualifiers can further be used with and without assistive devices or personal assistance. While neither devices nor personal assistance alter the impairments, they may remove limitations on functioning in

specific domains. This type of coding is particularly useful to identify how much the functioning of the individual would be limited without the assistive devices. The constructs and the operation of the qualifiers is set out in the next chart:

Construct	First qualifier	Second qualifier
Body Functions (b)	Generic qualifier with the negative scale used to indicate the extent or magnitude of an impairment Example: b175.3 to indicate a severe impairment in specific mental functions of language	None
Body Structure (s)	Generic qualifier with the negative scale used to indicate the extent or magnitude of an impairment Example: s730.3 to indicate a severe impairment of the upper extremity	Used to indicate the nature of the change in the respective body structure 0 no change in structure 1 total absence 2 partial absence 3 additional part 4 aberrant dimensions 5 discontinuity 6 deviating position 7 qualitative changes in structure, including accumulation of fluid 8 not specified 9 not applicable Example: s7300.32 to indicate the partial absence of the upper extremity
Activity & Participation (d)	PERFORMANCE Generic qualifier Problem in the person's current environment Example: a5101.1_ to indicate mild difficulty with bathing the whole body with the use of	CAPACITY Generic qualifier Limitation without assistance Example: a5101._2 to indicate moderate difficulty

	assistive devices that are available to the person in his or her current environment	with bathing the whole body and implies that there is moderate difficulty without the use of assistive devices or personal help
Environmental Factors (e)	Generic qualifier, with negative and positive scale to denote extent of barriers and facilitators respectively Example: e145.2 to indicate that products for education are a moderate barrier. Conversely, e145+2 would indicate that products for education are a moderate facilitator	None

Underlying principles of ICF

There are general principles that underlay the conception of ICF as a health classification of functioning and disability, and are closely linked to the biopsychosocial model of disability. These principles are essential components of the model of ICF and guided the revision process.

UNIVERSALITY

A classification of functioning and disability should be applicable to all people irrespective of health condition. Therefore, ICF is about all people. It concerns everyone's functioning. Thus, it should not become a tool for labeling persons with disabilities as a separate group.

PARITY

There should not be, explicitly or implicitly, a distinction between different health conditions as 'mental' and 'physical' that affect the structure of content of a classification of functioning and disability. In other words, disability must not differentiated by aetiology.

NEUTRALITY

Wherever possible, domain names should be worded in neutral language so that the classification can express both positive and negative aspects of each aspect of functioning and disability.

ENVIRONMENTAL FACTORS

In order to complete the social model of disability, ICF includes Contextual Factors, in which environmental factors are listed. These factors range from physical factors such as climate and terrain, to social attitudes, institutions, and laws. Interaction with environmental factors is an essential aspect of the scientific understanding of the phenomena included under the umbrella terms 'functioning and disability'.

THE DOMAINS OF ICF

The domains of ICF are arranged in a hierarchy (Chapter, second, third and fourth level domains), which is reflected in the coding:

Level	Example	Coding
Chapter	Chapter 2: Sensory Functions and Pain	b2
Second level	Seeing Functions	b210
Third level	Quality of vision	b2102
Fourth level	Colour vision	b21021

The follow chart sets out the complete list of chapters in the ICF:

Body	
Function: Mental Functions Sensory Functions and Pain Voice and Speech Functions Functions of the Cardiovascular, Haematological, Immunological and Respiratory Systems Functions of the Digestive, Metabolic, Endocrine Systems Genitourinary and Reproductive Functions Neuromusculoskeletal and Movement-Related Functions Functions af the Skin and Related Structures	Structure: Structure of the Nervous System The Eye, Ear and Related Structures Structures Involved in Voice and Speech Structure of the Cardiovascular, Immunological and Respiratory Systems Structures Related to the Digestive, Metabolic and Endocrine Systems Structure Related to Genitourinary and Reproductive

	Systems Structure Related to Movement Skin and Related Structures
Activities and Participation	
Learning and Applying Knowledge General Tasks and Demands Communication Mobility Self Care Domestic Life Interpersonal Interactions and Relationships Major Life Areas Commmunity, Social and Civic Life	
Environmental Factors	
Products and Technology Natural Environment and Human-Made Changes to Environment Support and Relationships Attitudes Services, Systems and Policies	

.

The following chart gives some possible examples of disabilities that may be associated with the three levels of functioning linked to a health condition.

HEALTH CONDITION	IMPAIRMENT	ACTIVITY LIMITATION	PARTICIPATION RESTRICTION
Leprosy	Loss of sensation of extremities	Difficulties in grasping objects	Stigma of leprosy leads to unemployment
Panic Disorder	Anxiety	Not capable of going out alone	People's reactions leads to no social relationships
Spinal Injury	Paralysis	Incapable of using public transportation	Lack of accommodations in public transportation leads to

			no participation in religious activities
Juvenile diabetes	Pancreatic dysfunction	None (impairment controlled by medication)	Does not go to school because of stereotypes about disease
Vitiligo	Facial disfigurement	None	No participation in social relations owing to fears of contagion
Person who formally had a mental health problem and was treated for a psychotic disorder	None	None	Denied employment because of employer's prejudice

The next chart indicates how the different levels of disability are linked to three different levels of intervention.

	Intervention	Prevention
HEALTH CONDITION	Medical treatment/care Medication	Health promotion Nutrition Immunization
IMPAIRMENT	Medical treatment/care Medication Surgery	Prevention of the development of further activity limitations
ACTIVITY LIMITATION	Assistive devices Personal assistance Rehabilitation therapy	Preventive rehabilitation Prevention of the development of participation restrictions
PARTICIPATION RESTRICTION	Accommodations Public education Anti-discrimination law Universal design	Environmental change Employment strategies Accessible services

		Universal design Lobbying for change

CONCLUSION

ICF offers an international, scientific tool for the paradigm shift from the purely medical model to an integrated biopsychosocial model of human functioning and disability. It is a valuable tool in research into disability, in all its dimensions -- impairments at the body and body part level, person level activity limitations, and societal level restrictions of participation. ICF also provides the conceptual model and classification required for instruments to assess the social and built environment.

ICF will be an essential basis for the standardization of data concerning all aspects of human functioning and disability around the world.

ICF will be used by persons with disabilities and professionals alike to evaluate health care settings that deal with chronic illness and disability, such as rehabilitation centres, nursing homes, psychiatric institutions, and community services.

ICF will be useful for persons with all forms of disabilities, not only for identifying their health care and rehabilitative needs, but also in identifying and measuring the effect of the physical and social environment on the disadvantages that they experience in their lives.

From the viewpoint of health economics, ICF will help monitor and explain health care and other disability costs. Measuring functioning and disabilities will make it possible to quantify the productivity loss and its impact on the lives of the people in each society. The classification will also be of great use in the evaluation of intervention programmes.

In some of the developed countries, ICF and its model of disability have been introduced into legislation and social policy, across sectors. It is expected that ICF will become the world standard for disability data and social policy modeling and will be introduced in the legislation of many more countries around the globe.

In sum, ICF is WHO's framework for health and disability. It is the conceptual basis for the definition, measurement and policy formulations for health and disability. It is a universal classification of disability and health for use in health and health-related sectors.

THE WORLD-WIDE ICF NETWORK

For further information about ICF, and its application to regions or countries, contact the following organizations, agencies, and NGOs who form part of ICF collaborating network.

Collaborating Centers:

Australia:

Canada:

France:

Japan:

The Netherlands:

Nordic countries:

United Kingdom:

USA: Networks:

Australian Institute of Health and Welfare, GPO Box 570, Canberra ACT 2601, Australia
Contact: Ros Madden.

Canadian Institute for Health Information, 377 Dalhousie Street, Suite 200, Ottawa Ontario KIN9N8, Canada Contact: Janice Miller.

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Center for Standardization of Informatics in Health Care (CSIZ), Driebergseweg 3, 3708 JA Zeist, The Netherlands, Contacts: Willem Hirs and Marijke W. de Kleijn de Vrankrijker.

Department of Public Health and Caring Sciences, Uppsala Science Park, SE Uppsala Sweden
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National Center for Health Statistics, Room 850, 6525 Belcrest Road, Hyattsville MD 20782, USA
Contact: Paul Placek.

La Red de Habla Hispana en Discapacidades (The Spanish Network). Co- ordinator: Jose Luis Vazquez-Barquero, Unidad de Investigacion en Psiquiatria Clinical y Social Hospital Universitario "Marques de Valdecilla", Avda. Valdecilla s/n, Santander 39008 Spain.

The Council of Europe Committee of Experts for the Application of ICIDH, Council of Europe, F-67075, Strasbourg, France. Contact: Lauri Sivonen.

Participating Non Governmental Organizations:

Disabled Peoples International, 11 Belgrave Road, London SW1V 1RB, United Kingdom. Contact: Rachel Hurst.

European Disability Forum, Square Ambiorix, 32 Bte 2/A, B-1000, Bruxelles, Belgium. Contact: Frank Mulcahy.

European Regional Council for the World Federation of Mental Health (ERCWFM), Blvd Clovis N.7, 1000 Brussels, Belgium. Contact: John Henderson.

Inclusion International, 13D Chemin de Levant, F-01210, Ferney-Voltaire, France. Contact: Nancy Breitenbach

Rehabilitation International, 25 E. 21st Street, New York, NY 10010, USA. Contact: Judith Hollenweger, Chairman RI Education Commission, Institute of Special Education, University of Zurich, Hirschengraben 48, 8001 Zurich, Switzerland.

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Appendix 5: Inclusion and exclusion criteria

Inclusion criteria

a. Human studies.
b. Studies published in the English language.
c. Studies where participants are adults aged 18+ years and who are experiencing intrusive memories of trauma (clinical, i.e., have a diagnosis of PTSD, and sub-threshold populations will be considered).
d. Studies reporting on intrusive memories of a trauma-related event (either a real-life trauma or experimentally induced intrusive memories.)
e. Intrusive memories measured and analysed as a single symptom of PTSD, i.e., not part of the re-experiencing PTSD cluster.
f. Outcomes related to the measurement of severity or changes in functioning, as defined by the World Health Organisation (WHO) International Classification of Functioning, Disability and Health (ICF).
g. Studies using quantitative methodology.
h. Studies at case series level of evidence or higher (i.e., case control studies, cohort studies, randomised controlled trials).
i. Studies employing a variety of designs, including, prospective, longitudinal and cross-sectional.

Exclusion criteria

a. Animal models.
b. Studies that measure intrusive thoughts alone.

c. Studies where there is a direct predictive relationship between functioning outcomes (y) and intrusive memories (x), i.e., y → x. Specifically, studies where the analysis or design are such that functioning is measured at T1 and intrusive memories at T2 (or beyond), will not be included.
d. Qualitative studies.
e. Case reports/case studies.

Appendix 6: NIH quality assessment tools used

Quality Assessment tool for Observational Cohort and Cross-sectional studies

Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?			
2. Was the study population clearly specified and defined?			
3. Was the participation rate of eligible persons at least 50%?			
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?			
5. Was a sample size justification, power description, or variance and effect estimates provided?			

Criteria	Yes	No	Other (CD, NR, NA)*
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?			
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?			
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?			
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
10. Was the exposure(s) assessed more than once over time?			

Criteria	Yes	No	Other (CD, NR, NA)*
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
12. Were the outcome assessors blinded to the exposure status of participants?			
13. Was loss to follow-up after baseline 20% or less?			
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?			

Quality Rating (Good, Fair, or Poor)
Rater #1 initials:

Quality Rating (Good, Fair, or Poor)
Rater #2 initials:
Additional Comments (If POOR, please state why):

*CD, cannot determine; NA, not applicable; NR, not reported

Quality Assessment Tool for Controlled Intervention Studies

Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the study described as randomized, a randomized trial, a randomized clinical trial, or an RCT?			
2. Was the method of randomization adequate (i.e., use of randomly generated assignment)?			

Criteria	Yes	No	Other (CD, NR, NA)*
3. Was the treatment allocation concealed (so that assignments could not be predicted)?			
4. Were study participants and providers blinded to treatment group assignment?			
5. Were the people assessing the outcomes blinded to the participants' group assignments?			
6. Were the groups similar at baseline on important characteristics that could affect outcomes (e.g., demographics, risk factors, co-morbid conditions)?			
7. Was the overall drop-out rate from the study at endpoint 20% or lower of the number allocated to treatment?			
8. Was the differential drop-out rate (between treatment groups) at endpoint 15 percentage points or lower?			

Criteria	Yes	No	Other (CD, NR, NA)*
9. Was there high adherence to the intervention protocols for each treatment group?			
10. Were other interventions avoided or similar in the groups (e.g., similar background treatments)?			
11. Were outcomes assessed using valid and reliable measures, implemented consistently across all study participants?			
12. Did the authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power?			
13. Were outcomes reported or subgroups analyzed prespecified (i.e., identified before analyses were conducted)?			
14. Were all randomized participants analyzed in the group to which they were originally assigned, i.e., did they use an intention-to-treat analysis?			

Quality Rating (Good, Fair, or Poor)
Rater #1 initials:
Rater #2 initials:
Additional Comments (If POOR, please state why):

Quality Assessment Tool for Assessing Case Series

Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the study question or objective clearly stated?			
2. Was the study population clearly and fully described, including a case definition?			
3. Were the cases consecutive?			
4. Were the subjects comparable?			
5. Was the intervention clearly described?			

Criteria	Yes	No	Other (CD, NR, NA)*
6. Were the outcome measures clearly defined, valid, reliable, and implemented consistently across all study participants?			
7. Was the length of follow-up adequate?			
8. Were the statistical methods well-described?			
9. Were the results well-described?			

Quality Rating (Good, Fair, or Poor)
Rater #1 initials:
Rater #2 initials:
Additional Comments (If POOR, please state why):

*CD, cannot determine; NA, not applicable; NR, not reported

Appendix 7: PRISMA checklist for Systematic Reviews

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	12
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	13
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	16
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	17
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	19
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	17-18
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Appendix 2
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	18-21
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	21
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	24
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	24
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	22-23
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	22
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing	N/A

Section and Topic	Item #	Checklist item	Location where item is reported
		summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	N/A
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	22-23
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	22
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	23-25
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	N/A
Study characteristics	17	Cite each included study and present its characteristics.	45-52
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	32-34
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	45-52
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	29-37
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	37-44
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	55-57
	23b	Discuss any limitations of the evidence included in the review.	58-59

Section and Topic	Item #	Checklist item	Location where item is reported
	23c	Discuss any limitations of the review processes used.	58-59
	23d	Discuss implications of the results for practice, policy, and future research.	57, 58, 60
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	17
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	N/A
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	N/A
Competing interests	26	Declare any competing interests of review authors.	N/A
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Appendices

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

Appendix 8: SWiM guidance

Table 1
Synthesis Without Meta-analysis (SWiM) items: SWiM is intended to complement and be used as an extension to PRISMA.

SWiM reporting item	Item description	Page in manuscript where item is reported	Other*
Methods			
1 Grouping studies for synthesis	1a) Provide a description of, and rationale for, the groups used in the synthesis (eg, groupings of populations, interventions, outcomes, study design)	20-21 and 22-23	
	1b) Detail and provide rationale for any changes made subsequent to the protocol in the groups used in the synthesis	N/A	
2 Describe the standardised metric and transformation methods used	Describe the standardised metric for each outcome. Explain why the metric(s) was chosen and describe any methods used to transform the intervention effects, as reported in the study, to the standardised metric, citing any methodological guidance consulted	N/A	
3 Describe the synthesis methods	Describe and justify the methods used to synthesise the effects for each outcome when it was not possible to undertake a meta-analysis of effect estimates	22-23	
4 Criteria used to prioritise results for summary and synthesis	Where applicable, provide the criteria used, with supporting justification, to select the particular studies, or a particular study, for the main synthesis or to draw conclusions from the synthesis (eg, based on study design, risk of bias assessments, directness in relation to the review question)	25	
5 Investigation of heterogeneity in reported effects	State the method(s) used to examine heterogeneity in reported effects when it was not possible to undertake a meta-analysis of effect	N/A	

SWiM reporting item	Item description	Page in manuscript where item is reported	Other*
	estimates and its extensions to investigate heterogeneity		
6 Certainty of evidence	Describe the methods used to assess the certainty of the synthesis findings	30-34 and Table 4	
7 Data presentation methods	Describe the graphical and tabular methods used to present the effects (eg, tables, forest plots, harvest plots)	25 and Tables 2 and 4	
	Specify key study characteristics (eg, study design, risk of bias) used to order the studies, in the text and any tables or graphs, clearly referencing the studies included		
Results			
8 Reporting results	For each comparison and outcome, provide a description of the synthesised findings and the certainty of the findings. Describe the result in language that is consistent with the question the synthesis addresses, and indicate which studies contribute to the synthesis	>37	
Discussion			
9 Limitations of the synthesis	Report the limitations of the synthesis methods used and/or the groupings used in the synthesis and how these affect the conclusions that can be drawn in relation to the original review question	58-59	

PRISMA=Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

- * If the information is not provided in the systematic review, give details of where this information is available (eg, protocol, other published papers (provide citation details), or website (provide the URL)).

Appendix 9: Full quality assessment of all included studies (*n* = 17)

Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies	**Exposure**	**Outcome**	**1. Research question**	**2. Study population**	**3. Participation rate >50%**	**4. Groups recruited from the same population and uniform eligibility criteria**	**5. Sample size justification**	**6. Exposure assessed prior to outcome measurement**	**7. Sufficient timeframe to see an effect**	**8. Different levels of the exposure of interest**	**9. Exposure measures and assessment**	**10. Repeated exposure assessment**	**11. Outcome measures**	**12. Blinding of outcome assessors**	**13. Follow-up rate**	**14. Confounders controlled/ statistically adjusted**	**Quality Rating (Good, Fair, Poor)**	**Inter-rater rating**
Alsawy et al., (2015)	Intrusive memories	Auditory hallucinations	YES	YES	CD	YES	NO	NO	NO	YES	YES	NO	YES	NA	NA	YES	**Poor**	
Brand et al. (2020)	Intrusive memories	Auditory hallucinations	YES	YES	NR	YES	NO	YES	YES	YES	NO	YES	PARTLY*	NR	YES	YES	**Fair**	**Fair**
Briddon et al., (2015)	Involuntary memories	Well-being	YES	YES	YES	YES	NO*	NO	NO	YES	YES**	NO	YES	NR	NO	YES	**Fair**	
Bryant et al., (2017)	Traumatic injury	PTSD symptoms	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO	YES	NA	NO	PARTLY*	**Fair**	**Fair**
Evans, et al., (2007)	Intrusive memories	Rumination	NO	YES	YES	PARTLY*	YES	NO	NO	NO	CD**	NO	CD**	NA	NA	NO	**Poor**	

Fried et al., (2018)	Traumatic events	PTSD symptoms	YES	YES	NR	PARTLY*	NO	YES	YES	NO	NO	NO	YES	NR	NA	NO	**Poor**	
Holmes et al., (2017)	intrusive memories	Concentration	YES	YES	NR	PARTLY*	NO	NO**	NO	YES	NO	YES	NO	NA	NO***	NR	**Poor**	
Iyadurai et al., (2019)	Intrusive memories	Daily functioning	YES	NO*	YES	PARTLY**	NO	NO	NO	NO	NO	NO	NO	NR	NA	NO	**Poor**	
Kleim et al., (2013)	Intrusive memories	Emotional responses	YES	NO*	YES	PARTLY**	YES	NO	NO	YES	NO	YES	NO	NA	NA	YES	**Fair**	
Kleindienst et al., (2017)	Intrusive memories	Aversive inner tension	YES	YES	YES	YES	NO	NO	CD*	PARTLY**	NO***	YES	NO	NR	NA	NR	**Fair**	
Letzter-Pouw & Werner (2005)	Intrusive memories	Physical health outcomes (IADLs, ADLs)	YES	NO*	NR	NR	NO	NO	NO	YES	YES	NO	NO	NR	NA	NO	**Poor**	**Poor**
Luik et al., (2019)	Intrusive memories	Sleep disturbance	YES	YES	YES	YES	YES	YES	YES	YES	NO*	YES	YES	NO	YES	YES	**Good**	
Ron & Shamai (2011)	Intrusive memories	Personal level of stress	YES	YES	CD	NO	NO	NO	NO	YES	NO	NO	YES	NR	NA	NO	**Poor**	
Ron & Shamai (2014)	Intrusive memories	Personal level of stress	YES	YES	CD	NO	NO	NO	NO	YES	NO	NO	YES	NR	NA	NO	**Poor**	
Speckens et al., (2007)	Intrusive memories	Emotions & Rumination	YES	YES	NR	YES	NO	NO	NO	NO	NO*	NO	NO	NA	NA	NO	**Poor**	

Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies	**Comments** (asterisks correspond to those in the table above)	**Comments for studies rated as 'Poor'**
Alsawy et al., (2015)		This is a cross-sectional design where poor methodological rigour makes it difficult to ascertain the relationship between outcome and exposure. The strength of the design included a large sample and a well-defined population.
Brand et al. (2020)	*outcome assessed both by self-report and by a validated measure.	N/A
Briddon, Isaac & Slade (2015)	*They did boostrapping on 5,000 samples and also included confidence intervals. **Used the TMQ intrusion subscale and adapted two of the questions to fit their study. So, the measure itself is validated, but the adaptation may not be.	N/A

Bryant et al., (2017)	*partial correlations were used to control for 'other symptoms' (of PTSD) but no other variables, e.g., demographics were not controlled, which may have represented significant confounders.	N/A
Evans, Ehlers, Mezey & Clark (2007)	*recruitment time period not stated, but imprisonment was within a 20-month period. Inclusion criteria not specified. **"Intrusion Interview" used - this has been used in previous studies, but it is unclear whether this is a reliable or validated measure.	Cross-sectional design with poor replicability. Measures used have questionable validity and reliability. Difficult to ascertain association between variables.
Fried et al., (2018)	*inclusion/exclusion criteria not reported.	Whilst the strength of this study lies in a large, multicultural sample, there are aspects of the study which are either missing (not reported) or have not been conducted, e.g., power analyses and controlling for confounding variables. Replicability of this study would be challenging.
Holmes et al., (2017)	*inclusion/exclusion criteria not reported. **Both questions about intrusive memories and concentration were asked at interview - both related to 'over the past week'. *** 22% dropped-out at timepoint of returning Intrusion Diary.	There is a lot of missing information, including inclusion/exclusion criteria; small sample size (feasibility study); measures are not valid nor reliable.
Iyadurai et al., (2019)	*Recruitment period not specified, and very limited demographic information reported. **Inclusion/exclusion criteria are not specified.	There are very many details missing. Retrospective account of traumatic events - highly unreliable as it relies on memory. Time since trauma is not reported, nor controlled for.

Kleim et al., (2013)	*Doesn't specify where (location) of recruitment i.e., where flyers were displayed nor recruitment period. **whether participants were recruited from the same time period is not specified.	There are elements of this study that would be difficult to replicate, for example, the location or recruitment period are unknown. It is unclear how valid or reliable to measures are.
Kleindienst et al., (2017)	*cannot be determined if aversive inner tension measured before or after intrusive memory measurement taken. If after, then it would likely be a 'YES' because you get an emotional response immediately after experiencing intrusive memories. **Measures as a continuous variable (frequency of intrusive memories), however, when analysed with aversive inner tension, only two categories were considered: intrusive memory-periods vs. >1 intrusive memory. ***frequency of intrusive memories is recorded using an app - not clear how valid or reliable this is.	N/A
Letzter-Pouw & Werner (2005)	*location of recruitment and recruitment period missing.	Many study details were missing, e.g., patient demographics and controlling for confounders and any kind of power analysis. I think replicability would be difficulty. It would also be hard to establish internal or external validity.
Luik et al., (2019)	*frequency measure of IMs in a daily diary - not a validated or reliable measure.	
Ron & Shamai (2011)		There are key aspects of the study missing, e.g., inclusion and exclusion criteria. It's difficult to see any sort of meaningful

		association between outcome and exposure given the cross-sectional design. Crucially, as it is a study of trauma related intrusive memories, and social workers may have been recruited from non-terror exposed settings (and this is inconsistent across the recruited population), it's difficult to trust the associations found.
Ron & Shamai (2014)		There are key aspects of the study missing, e.g., inclusion and exclusion criteria. It's difficult to see any sort of meaningful association between outcome and exposure given the cross-sectional design. Crucially, as it is a study of trauma-related intrusive memories, and nurses may have been recruited from non-terror exposed settings (and this is inconsistent across the recruited population), it's difficult to trust the associations found.
Speckens et al., (2007)	*Number of intrusive memories, frequency and duration measured but this level is not analysed with emotion, therefore 'NO'.	Cross-sectional design makes it difficult to ascertain reliable relationship between exposure and outcome. Lots of detail missing and unreliable measures.

Quality Assessment Tool for RCTs	1. Described as an RCT	2. Randomisation method adequacy	3. Treatment allocation concealment	4. Blinding of participants and treatment providers	5. Blinding of assessors of outcome	6. Similarity of groups at baseline	7. End-point drop-out rate <20% for treatment group	8. Differential between-group end-point drop-out rate <15%	9. High adherence to protocol	10. Avoidance/ similarity of other interventions in groups	11. Outcome measures	12. Sample size and power >80%	13. Prespecified outcomes/ subgroup analysis	14. Intention-to-treat analysis	Quality Rating (Good, Fair, Poor)	Inter-rater rating	Comments
Kanstrup et al., (2021)	YES	YES	YES	PARTLY*	PARTLY **	NR***	NO	NO	YES	NR	NO	PARTLY ****	YES	YES	**Fair**	**Fair**	*Participants were blinded, researchers were not. **Blinded to baseline ones but others not reported. ***Statistical comparisons not reported. ****Yes at week 1 but not any later outcome timepoints

Quality Assessment Tool for case series	1. Study question/ objective clear	2. Study population description	3. Consecutive cases	4. Comparable subjects	5. Clear description of intervention	6. Outcome measures	7. Adequate length of follow-up	8. Statistical methods well-described	9. Results well-described	Quality Rating (Good, Fair, Poor)	Inter-rater rating	Comments
Kanstrup et al., (2020)	YES	YES	NR	CD*	YES	NO	NA	YES**	YES	**Fair**	**Fair**	* No statistical methods to check whether cases are comparable. **Descriptive analyses and visual inspection used only

Paper B Appendices

Appendix 10 Inclusion and exclusion criteria for earlier study designs

Appendix 11 Sociodemographic information form

Appendix 12 List of intrusive memories form

Appendix 13 Intrusive memory diary

Appendix 14 Intrusive memory characteristics from intrusive memory diary

Appendix 15 Retrospective Intrusive Memory measure

Appendix 16 Participant feedback questionnaire

Appendix 17 Researcher training to deliver the brief behavioural intervention

Appendix 18 Instructions for accessing Tetris

Appendix 19 Ethical approval from OXICPTR (funding approval letter), CTRG (Sponsor), HRA, MS IDREC, and Trust management approval from OUH, RBH and SCAS

Appendix 20 Sample recruitment material: study poster and recruitment email

Appendix 21 Participant information sheet

Appendix 22 Verbal consent form

Appendix 23 Signposting information sheet

Appendix 24 Participant personal information form

Appendix 25 Tau-*U* analysis output

Appendix 26 Baseline stability assessment for secondary outcome measures

Appendix 27 Data accuracy check

Appendix 28 Themes of intrusive memory content

Appendix 29 Individual participant time course graphs

Appendix 30 Graphs of individual mental health symptoms

Appendix 31 Participant feedback table

Appendix 32 Intervention booster information

Appendix 33 Impact of COVID-19 on participants

Appendix 10: Inclusion and exclusion criteria for earlier study designs

Inclusion and exclusion criteria applicable at the time of recruitment of:

P1:

Inclusion criteria

- Aged 18 or above
- Able to read, write and speak in English
- Able and willing to provide informed consent and complete study procedures
- Clinical staff working in urgent care hospital departments at the John Radcliffe and Royal Berkshire Hospital
- Experiencing intrusive memories, which are problematic to them (self-report)
- Reporting the occurrence of at least two intrusive memories of a work-related traumatic incident in the week prior to beginning the study
- Able and willing to talk about the intrusive memories
- Able and willing to complete an electronic intrusive memory diary over a six-week period
- Able and willing to play Tetris on a hand-held device
- Not currently undergoing treatment for PTSD or its symptoms

Exclusion criteria

- A participant will be excluded if they have less than or equal to 1 targeted intrusive memory per week for all weeks during the baseline period.
- Participants will also be excluded if they start undergoing treatment for PTSD or its symptoms during the course of the study.

P2:

Inclusion criteria

- Aged 18 or above
- Able to read, write and speak in English
- Able and willing to provide informed consent and complete study procedures
- Clinical staff working in urgent care hospital departments at the John Radcliffe and Royal Berkshire Hospital
- Experiencing intrusive memories, which are problematic to them (self-report)
- Reporting the occurrence of at least two intrusive memories of a work-related traumatic incident in the week prior to beginning the study
- Able and willing to talk about the intrusive memories
- Able and willing to complete an electronic intrusive memory diary over an eight-week period
- Able and willing to play Tetris on a hand-held device
- Not currently undergoing treatment for PTSD or its symptoms

Exclusion criteria

- A participant will be excluded if they have less than or equal to 1 targeted intrusive memory per week for all weeks during the baseline period.
- Participants will also be excluded if they start undergoing treatment for PTSD or its symptoms during the course of the study.

P3-P14:

Inclusion Criteria

- Aged 18 or above
- Able to read, write and speak in English
- Able and willing to provide informed consent and complete study procedures
- NHS hospital and pre-hospital clinical staff
- Experiencing intrusive memories, which are problematic to them (self-report)
- Reporting the occurrence of at least two intrusive memories of a work-related traumatic incident in the week prior to beginning the study
- Able and willing to talk about the intrusive memories
- Able and willing to complete an electronic intrusive memory diary over a 2-3 week period
- Able and willing to play Tetris on a hand-held device
- Not currently undergoing treatment for PTSD or its symptoms

Exclusion Criteria

- Participants will be excluded if they have fewer than two targeted intrusive memories per week
- Participants will also be excluded if they start undergoing treatment for PTSD or its symptoms during the course of the study.

Appendix 11: Sociodemographic information form

Sociodemographic Information form (completed online in Qualtrics)

Participant ID (e.g., C012)

Today's Date (dd/mm/yyyy)

Gender
- Male
- Female
- Other
- Prefer not to say

Age (years)

Years in education (from first grade at school)

Marital status
- Single
- Married or cohabiting
- Divorced/separated
- Widowed

Ethnic group
- White British
- Any other white background
- Indian
- Pakistani
- Bangladeshi
- Black Caribbean
- Black African
- Chinese
- Mixed background
- Any other background (specify)

What is your job role?
- Doctor
- Nurse
- Healthcare assistant
- Paramedic
- Other (specify)

What is your NHS banding level?
- For doctors:
  - FY1
  - FY2
  - Registrar
  - Specialty registrar

Consultant

For nurses/HCA's/paramedics/other:

Band 3
Band 4
Band 5
Band 6
Band 7
Band 8

How long have you been working in your current job role for (ICU staff/ED staff/paramedic etc.)? (months)

Appendix 12: List of intrusive memories form

List of intrusive memories questionnaire

Participant ID (e.g., 001)

Today's Date (dd/mm/yyyy)

"Could you please briefly put the worst moments of the event that emerge as intrusive memories into words? They could come back as a movie, still frames or snapshots. You do not need to think about them in detail, just briefly describe the images that pop up. What to do you see?"

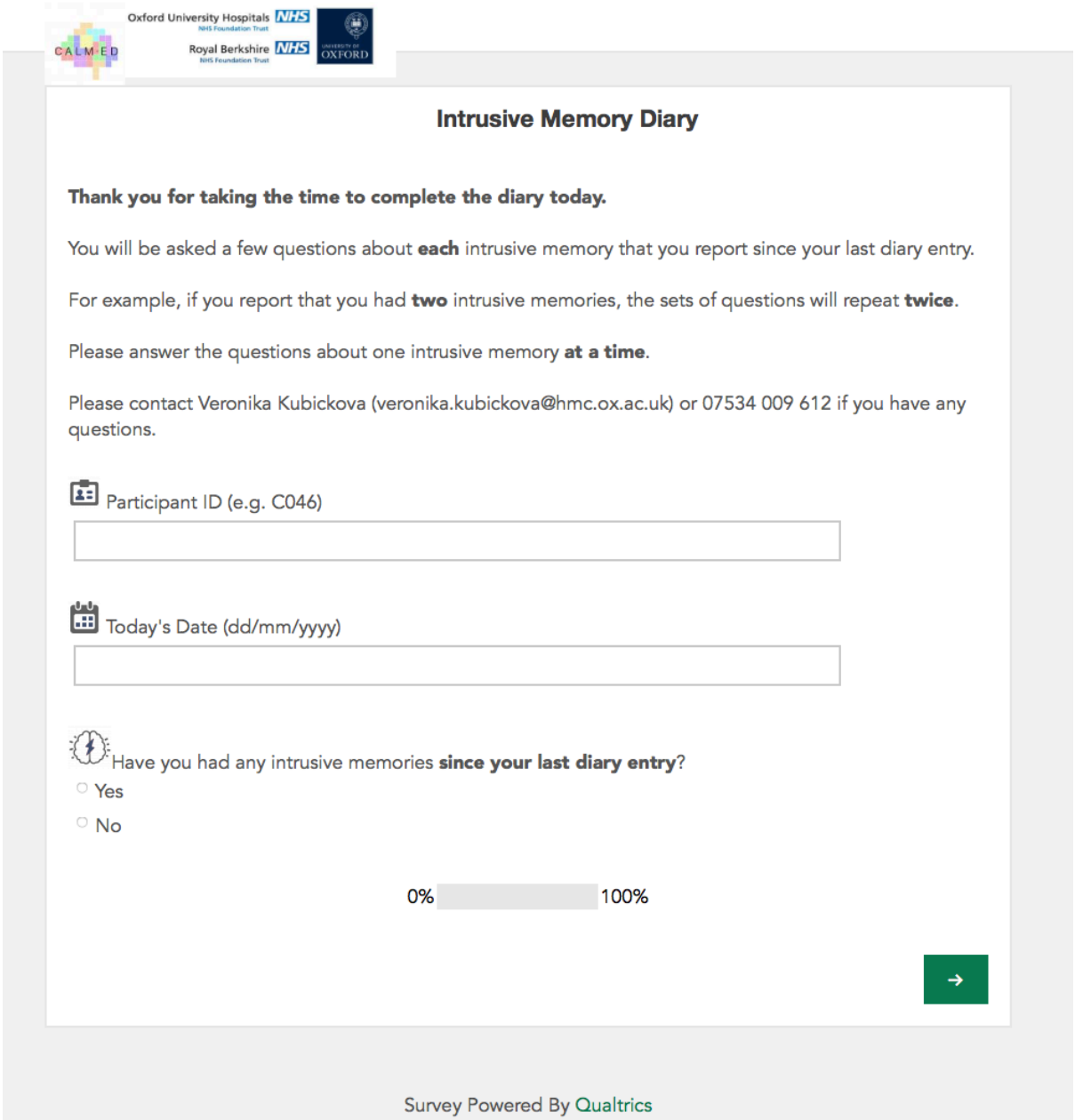
Ask the participant to think of a few words that describe each intrusive memory, i.e., a label (this will be used in the Intrusive Memory diary).

Record the number of each intrusive memory over the last week.

For each new event ask:
"When did the event for which you're having the intrusive memory occur?" [record month and year]

Think together with the participant:
Which intrusive memory is generally the most frequent and bothersome? Which one are we most likely to target with the intervention?

Appendix 13: Intrusive memory diary



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Intrusive Memory Diary

Thank you for taking the time to complete the diary today.

You will be asked a few questions about **each** intrusive memory that you report since your last diary entry.

For example, if you report that you had **two** intrusive memories, the sets of questions will repeat **twice**.

Please answer the questions about one intrusive memory **at a time**.

Please contact Veronika Kubickova (veronika.kubickova@hmc.ox.ac.uk) or 07534 009 612 if you have any questions.

Participant ID (e.g. C046)

Today's Date (dd/mm/yyyy)

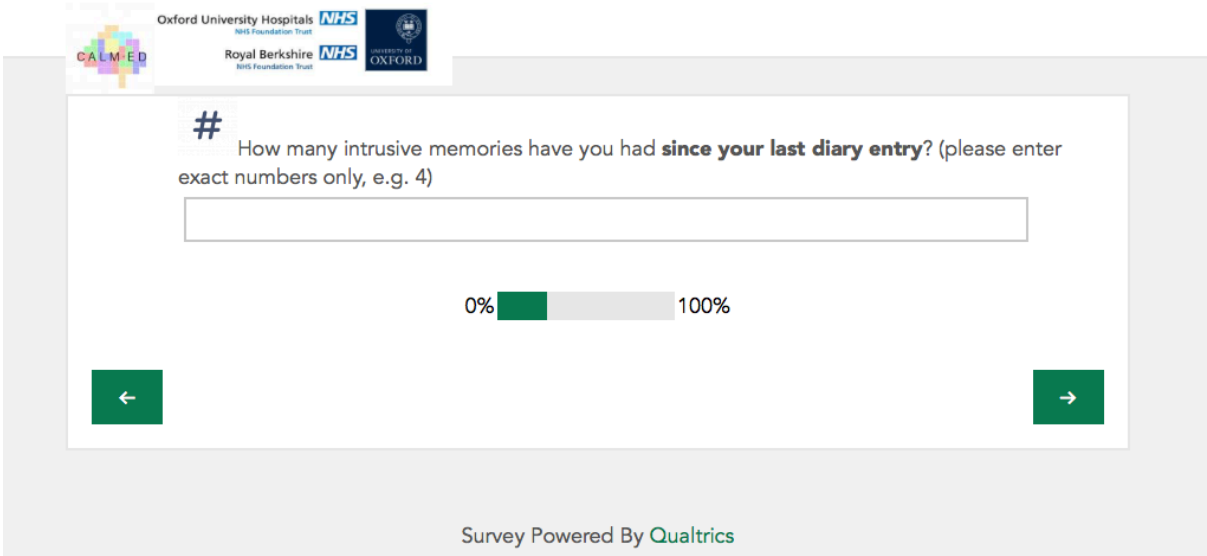
Have you had any intrusive memories **since your last diary entry**?

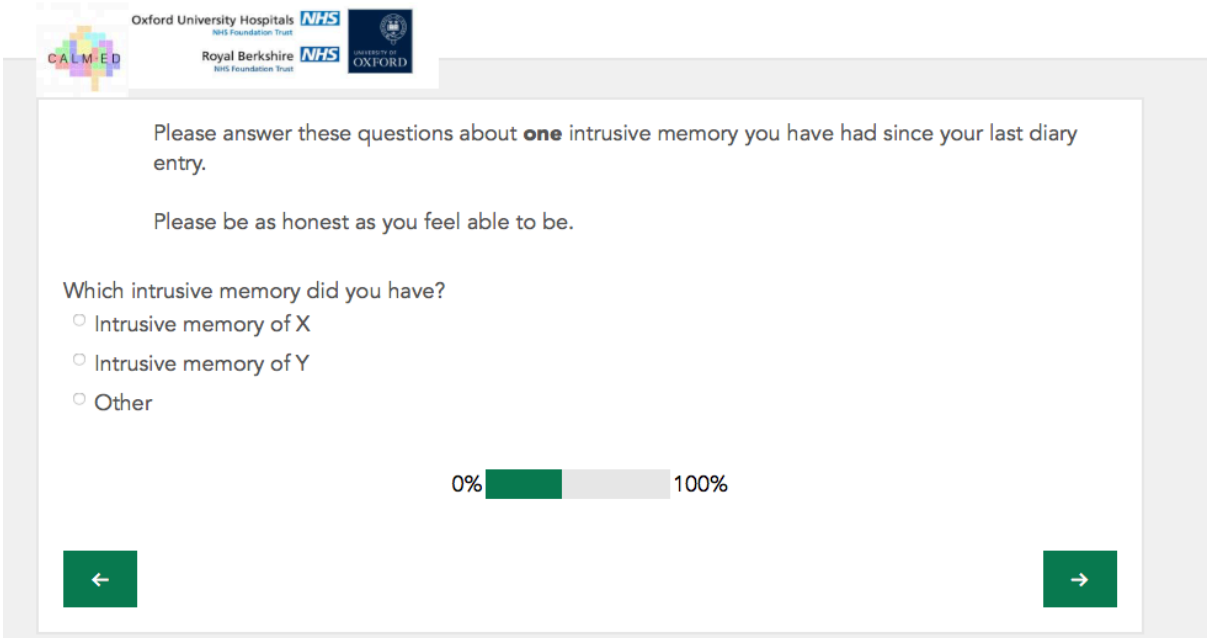
- Yes
- No

0% 100%

→

Survey Powered By Qualtrics


Oxford University Hospitals NHS
Royal Berkshire NHS
CALM-ED
#
How many intrusive memories have you had since your last diary entry? (please enter exact numbers only, e.g. 4)
0%
100%
Survey Powered By Qualtrics


Oxford University Hospitals NHS
Royal Berkshire NHS
CALM-ED
Please answer these questions about one intrusive memory you have had since your last diary entry.
Please be as honest as you feel able to be.
Which intrusive memory did you have?
Intrusive memory of X
Intrusive memory of Y
Other
0%
100%
Survey Powered By Qualtrics

Were you **at work** when you had the intrusive memory of Intrusive memory of X?

- Yes
- No

Approximate time that intrusive memory of Intrusive memory of X popped into your mind e.g. 13:45 (24h clock)

Approximately **how long** did the intrusive memory of Intrusive memory of X **bother** you for?

- <1 min
- 1-5 min
- 6-10 min
- 11-30 min
- 31-60 min
- >60 min

How **distressing** was the intrusive memory of Intrusive memory of X?

Not at all distressing — Extremely distressing

0 1 2 3 4 5 6 7 8 9 10

Intrusive memory of X

How **vivid** was the intrusive memory of Intrusive memory of X?

Not at all vivid — Extremely vivid

0 1 2 3 4 5 6 7 8 9 10

Intrusive memory of X

How much did the intrusive memory of Intrusive memory of X disrupt your **concentration**?

Not at all — A great deal

0 1 2 3 4 5 6 7 8 9 10

Intrusive memory of X

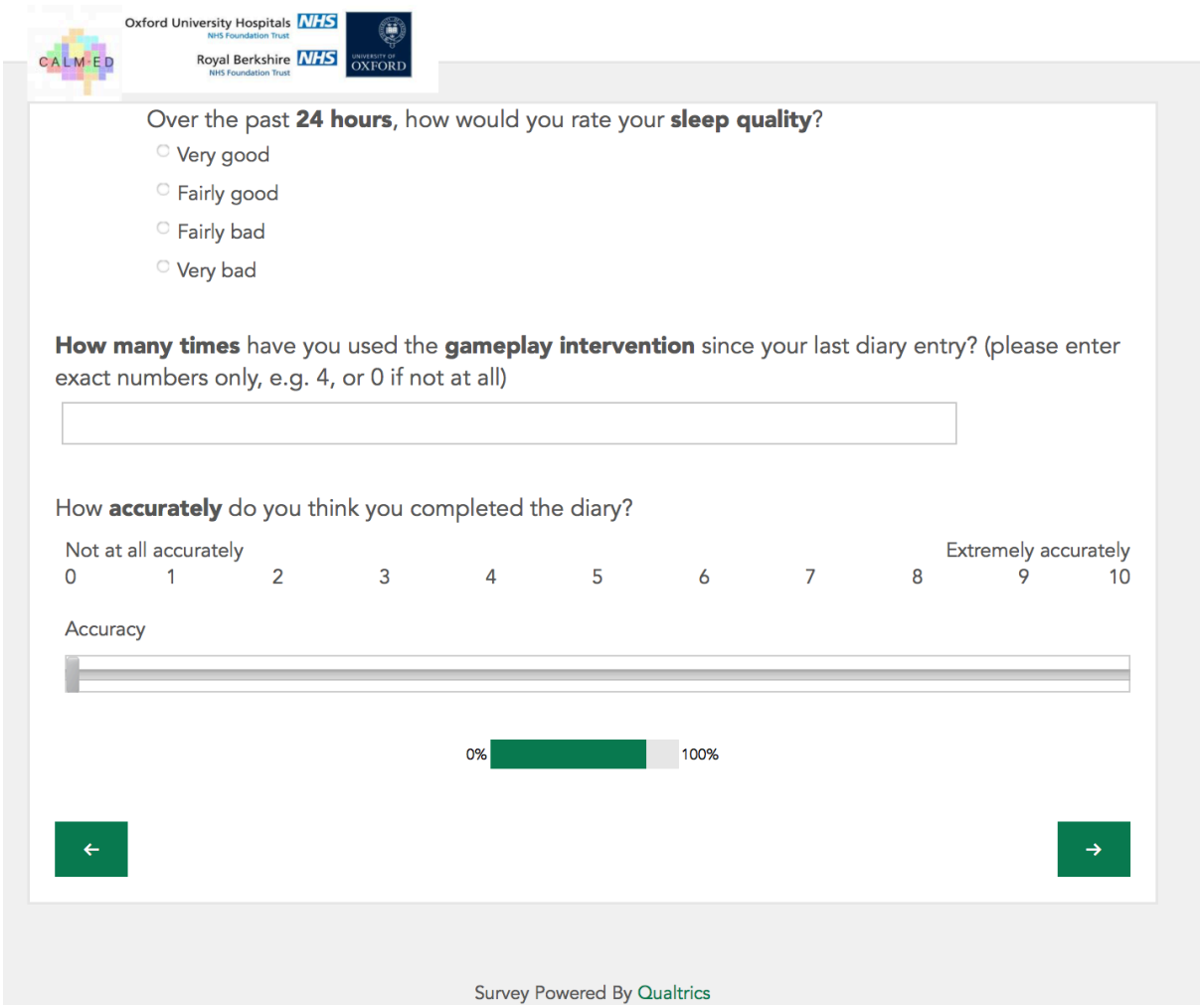
How much did the intrusive memory of Intrusive memory of X **disrupt the task** you were doing?

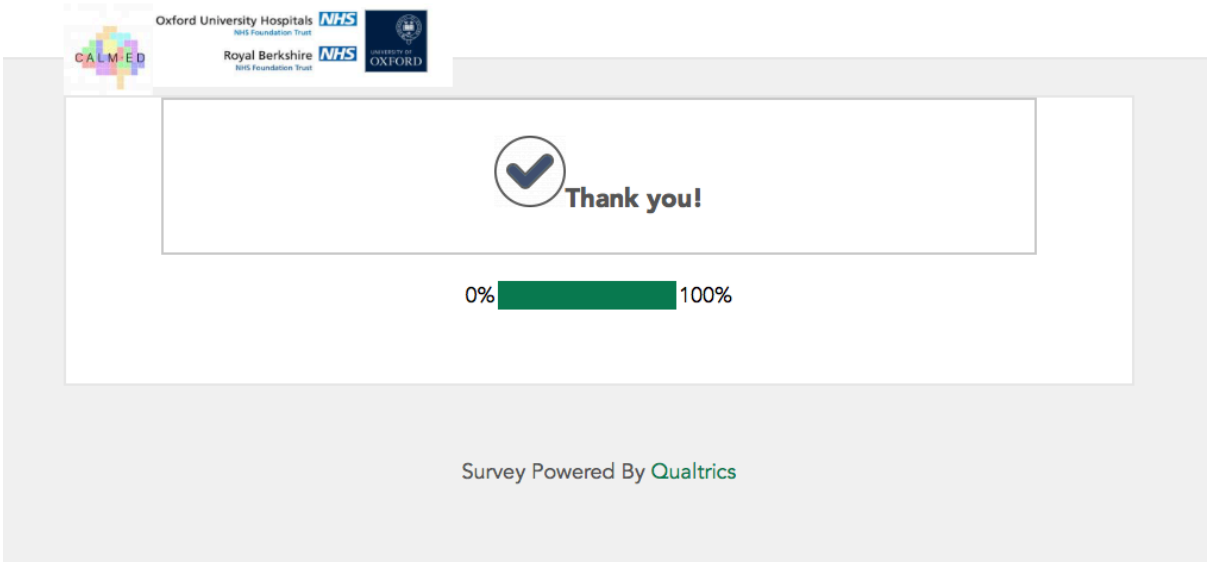
Not at all — A great deal

0 1 2 3 4 5 6 7 8 9 10

Intrusive memory of X

0% 100%


Oxford University Hospitals NHS
NHS Foundation Trust
Royal Berkshire NHS
NHS Foundation Trust
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Over the past 24 hours, how would you rate your sleep quality?
Very good
Fairly good
Fairly bad
Very bad
How many times have you used the gameplay intervention since your last diary entry? (please enter exact numbers only, e.g. 4, or 0 if not at all)
How accurately do you think you completed the diary?
Not at all accurately
Extremely accurately
0 1 2 3 4 5 6 7 8 9 10
Accuracy
0%
100%
Survey Powered By Qualtrics


Oxford University Hospitals NHS
NHS Foundation Trust
Royal Berkshire NHS
NHS Foundation Trust
CALM-ED
Thank you!
0%
100%
Survey Powered By Qualtrics

Appendix 14: Intrusive memory characteristics and functioning from intrusive memory diary

Appendix 14 contains information about the following:

(a) A description of what data was collected using the intrusive memory diary.

(b) Table A14 which details means and standard deviations of baseline and post-intervention data collected using the intrusive memory diary per participant.

(c) Statistical analyses of data detailed in Table A1.

(d) Categorical data (length of time intrusions were bothersome for and daily sleep quality ratings) displayed graphically.

(a) A description of what data was collected using the intrusive memory diary

In the intrusive memory diary, for each intrusive memory, participants were also asked to record how vivid the intrusive memory was (rated from 0 = *not at all,* 10 = *extremely*), how distressing (0 = *not at all,* 10 = *extremely*), how much it disrupted their concentration (0 = *not at all*, 10 = *a great deal*), how much it disrupted the task at hand (0 = *not at all*, 10 = *a great deal*), length of time the intrusion bothered the participant (*<1 min*, *1-5 min*, *6-10 min*, *11-30 min*, *31-60 min*, *>60 min*), sleep quality over the past 24 hours (P3-P14 only; *very good*, *fairly good*, *fairly bad*, *very bad*), the approximate time the intrusive memory came into mind (open-ended response using 24-hour clock).

Table A14 which details means and standard deviations of baseline and post-intervention data collected using the intrusive memory diary per participant.

Table A14. Mean and standard deviations of secondary intrusive memory diary data of all intrusive memories, excluding new intrusive memories, i.e., those not accounted for at baseline assessment, including distress, vividness, concentration and task disruption ratings for all participants during the baseline period ("A") and post-intervention period ("B"). Where there was only one rating at either baseline or post-intervention period, no standard deviation could be calculated. N/a means that there were no intrusive memories reported in that phase for that participant.

	Distress		Vividness		Concentration		Disrupt task	
Participant	‘A' mean (SD)	‘B' mean (SD)	‘A' mean (SD)	‘B' mean (SD)	‘A' mean (SD)	‘B' mean (SD)	‘A' mean (SD)	‘B' mean (SD)
P1	6.4 (1.17)	5 (4.24)	6.8 (1.62)	6 (1.41)	3.2 (2.10)	3.5 (2.12)	1.9 (1.37)	3 (2.83)
P2	5.22 (1.90)	5.06 (2.00)	6.26 (1.82)	5.2 (2.12)	4.33 (2.14)	3.04 (1.43)	3.69 (2.28)	2.24 (1.24)
P3	1.83 (2.07)	3.31 (2.33)	4.44 (1.29)	6.19 (2.14)	1.33 (1.78)	4.89 (2.70)	3.83 (4.08)	4.81 (3.53)
P4	3.71 (0.76)	3.00	3.71 (0.95)	5.00	3.14 (1.68)	4.00	2 (1.15)	4.00
P5	4.3 (1.06)	4 (0.89)	7.9 (1.97)	7.17 (1.83)	3.4 (0.97)	3.33 (1.21)	2.7 (0.67)	2.67 (0.52)
P6	4 (2.16)	n/a	4.5 (1.73)	n/a	3 (1.83)	n/a	2.5 (1.29)	n/a
P7	6.08 (1.04)	6.5 (1.00)	9.69 (0.85)	8 (0)	3.92 (1.12)	4 (0.82)	3.62 (1.12)	3 (0.82)
P8	2.63 (1.77)	2.67 (0.58)	3.75 (2.25)	3.67 (1.15)	0.00	0.00	0.13 (0.35)	0.00
P9	4.67 (0.58)	6.5 (0.71)	6.33 (0.58)	7 (0)	6.67 (0.58)	8 (2.83)	5.67 (2.52)	4.5 (3.54)
P10	6.59 (1.34)	6.88 (0.88)	7.44 (1.45)	6.44 (2.12)	6.15 (1.23)	6.36 (1.04)	5.93 (1.64)	6.28 (1.57)
P11	4.75 (1.26)	3.83 (0.75)	4 (1.41)	2.33 (0.52)	4.25 (1.26)	3.33 (1.21)	3.25 (0.96)	3.17 (1.17)
P12	6.13 (1.26)	5.55 (1.04)	7.38 (1.09)	6.91 (1.04)	6.38 (1.54)	4.09 (1.30)	3.75 (2.29)	2.36 (1.21)
P13	7.33 (2.24)	7.54 (1.81)	6.89 (2.09)	7.08 (1.55)	6.89 (2.03)	7 (1.58)	7.11 (2.32)	6.85 (1.68)
P14	5.83 (1.72)	6.5 (0.58)	6.67 (1.51)	5 (2.58)	5.17 (1.72)	5.75 (0.50)	4 (2.10)	4 (0.82)

(c) Statistical analyses of data detailed in Table A14.

Paired samples *t*-tests were conducted to ascertain whether there are statistically significant changes in the vividness, distress, concentration and disruption to task at hand ratings from baseline to post-intervention for all intrusive memories, excluding new ones, as reported in the intrusive memory diary. There were no statistically significant reductions in baseline ($M = 5.04$, $SD = 1.61$) to post-intervention ($M = 5.10$, $SD = 1.62$)

ratings of distress $t(12) = -.26$, $p = .796$, baseline ($M = 6.25$, $SD = 1.81$) to post-intervention ($M = 5.86$, $SD = 1.58$) ratings of vividness $t(12) = 1.31$, $p = .216$, baseline ($M = 4.22$, $SD = 2.07$) to post-intervention ($M = 4.41$, $SD = 2.05$) ratings of concentration $t(12) = -.492$, $p = .632$, nor in baseline ($M = 3.66$, $SD = 1.84$) to post-intervention ($M = 3.61$, $SD = 1.79$) ratings of disruption to task at hand $t(12) = .19$, $p = .850$.

(d) Categorical data (length of time intrusions were bothersome for and daily sleep quality ratings) displayed graphically.

The length of time that intrusive memories were bothersome at baseline compared to the post-intervention period for all participants is shown in Figure A14.

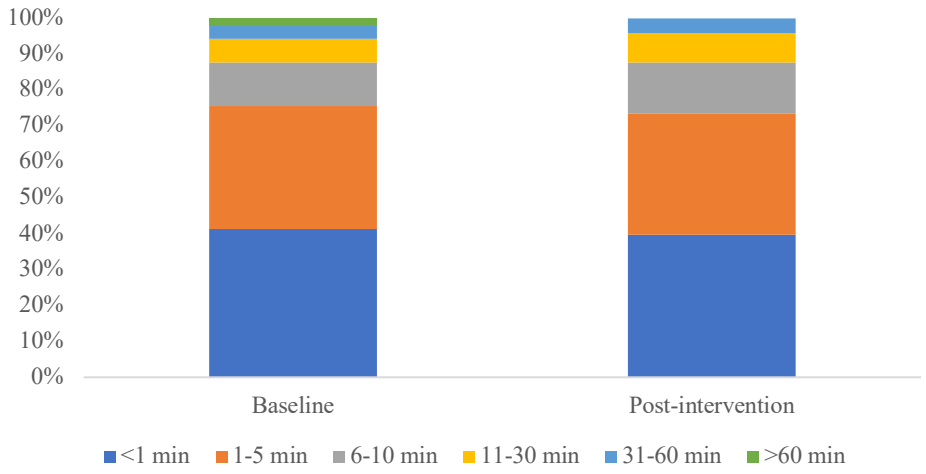


Figure A14a. Sums of ratings for the length of time intrusive memories were bothersome at baseline versus post-intervention as indicated on the intrusive memory diary ($n = 14$).

Ratings of sleep quality summed for baseline and post-intervention as indicated by participants three through to fourteen on the intrusive memory diary can be seen in Figure A14b.

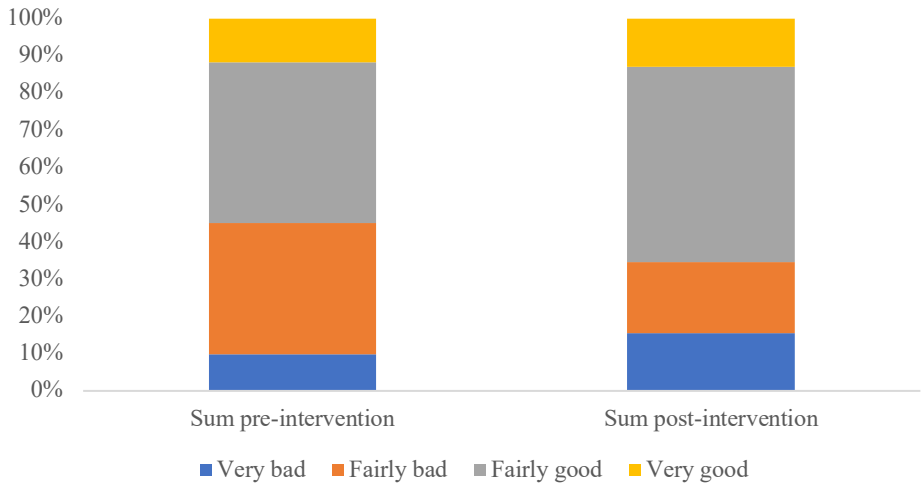


Figure A14b. Sums of sleep quality ratings at baseline versus post-intervention as indicated on the intrusive memory diary (n = 12).

Appendix 15: Retrospective Intrusive Memory measure

Retrospective Intrusive Memory measure

OVER THE LAST WEEK:

Have you had any intrusive memories? (i.e., images of a stressful event that popped into your mind when you didn't want them to)

YES **NO**

How many intrusive memories did you have?

[None (0), some (1-4), quite a few (5-10), lots (10-20), very many (21-30), a large amount (31-50), more (more than 50)]

How distressing were your intrusive memories?

[visual scale: 0 = not at all; 10 = extremely]

How vivid were your intrusive memories?

[visual scale: 0 = not at all; 10 = extremely]

How much did they disrupt your concentration?

[visual scale: 0 = not at all; 10 = a great deal]

How much did they disrupt the tasks you were doing?

[visual scale: 0 = not at all; 10 = a great deal]

Approximately how long did your intrusive memories bother you for?

[<1min, 1-5mins, 6-10mins, 11-30mins, 31-60mins, >60mins]

How much did your intrusive memories interfere with your night's sleep?

[visual scale: 0 = not at all; 10 = a great deal]

How much have your intrusive memories affected your ability to function in your daily life?

[visual scale: 0 = not at all; 10 = a great deal]

How have your intrusive memories affected your ability to function in your daily life in the past week?

[open-ended response]

Appendix 16: Participant feedback questionnaire

Feedback Questionnaire

This questionnaire asks you about your experience of taking part in the study. We very much value both positive and negative feedback, and your answers will be used to improve this research in the future, so please answer these questions as honestly as possible.

The computer game Tetris

How **easy** did you find playing Tetris whilst at work?

[Likert scale from 'not at all easy = 0' to 'extremely easy = 10']

How **helpful** did you find playing Tetris whilst at work?

[Likert scale from 'not at all helpful = 0' to 'extremely helpful = 10']

How **burdensome** did you find playing Tetris whilst at work?

[Likert scale from 'not at all burdensome = 0' to 'extremely burdensome = 10']

If you were experiencing intrusive memories in the future, how **willing** would you be to play Tetris if it was offered to you as something that would help?

[Likert scale from 'Extremely unwilling = 0' to 'extremely willing = 10']

If another staff member was having intrusive memories, how **confident** would you be in suggesting playing Tetris to them?

[Likert scale from 'Extremely unconfident = 0' to 'extremely confident = 10']

Do you have any suggestions for improving Tetris as something that might help with reducing intrusive memories after a traumatic event? Please note, we will explain how this might help when we contact you again to debrief you about the study.

Do you have any other comments about using Tetris as something that might help after a traumatic event?

<u>The study in general</u>

How **easy** did you find taking part in the study?

[Likert scale from 'not at all easy = 0' to 'extremely easy = 10']

How **burdensome** did you find taking part in the study?

[Likert scale from 'not at all burdensome = 0' to 'extremely burdensome = 10']

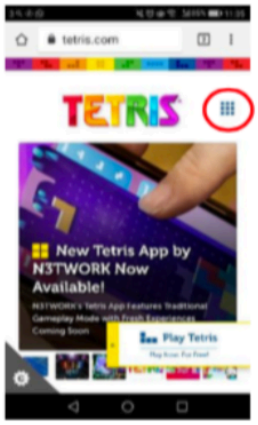
If we were to roll out the study on a larger scale, how could we improve the study (over and above anything you have already mentioned)?

Do you have any other comments about the study or your experience of taking part in the study (over and above anything you have already mentioned)?

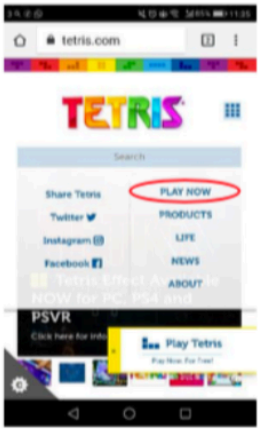
Appendix 17: Instructions for accessing Tetris

1) Go to the following link
https://tetris.com/

2) Click on the square symbol in the top right (circled in red):



3) Click on "PLAY NOW"



4) Go to Settings:



5) Set as follows: disable ghost piece and set music and sound fx volume to 0%;



Appendix 18: Researcher training to deliver the brief behavioural intervention

Training to deliver the intervention

To promote appropriate delivery of the intervention and adherence to the protocol, the researcher administering the intervention (VK) received training, feedback and monitoring from clinical psychologists/researchers who were experienced in delivering the intervention. First, the trainee attended a one-day remote (via video-call) research group training workshop providing key knowledge required to deliver the protocol. Learning included theoretical underpinnings and essential components of the intervention and wider protocol (e.g., communication with participants, identifying and recording intrusive memories, the brief memory reminder procedure, delivering mental rotation instructions to play Tetris, collecting the primary outcome). During this workshop, the researcher observed and practiced role-plays of these key elements with attending supervisors. Following this, the researcher ran further role-plays with LI to practice delivering the essential components of the intervention and wider protocol, and the filmed role-plays were formally evaluated according to protocol fidelity criteria by an independent rater. The researcher received further training in delivering the intervention by LI and another experienced researcher (MK) during a 1-hour video-call role-play session. Written protocols for baseline assessment, intervention delivery and outcome assessment were developed by VK and LI to ensure homogeneous delivery across participants. For the first three participants LI provided supervision, monitoring and checks of protocol fidelity via phone/video call after each baseline assessment, intervention session or primary outcome data collection. Thereafter the researcher contacted LI either during the participant session or immediately afterwards if any uncertainties or problems arose (e.g., regarding eligibility criteria or intervention delivery). Protocol fidelity was checked, and flexible adaptations discussed at regular supervision meetings. During recruitment and data

collection, the researcher attended regular group supervision via video call with other researchers using the intervention, during which experiences and best practice were shared, and feedback was received. Incoming data was continuously monitored by VK and LI.

Appendix 19: Ethical approval from OXICPTR (funding approval letter), CTRG (Sponsor), HRA, MS IDREC, and Trust management approval from OUH, RBH and SCAS

Oxford Health NHS
NHS Foundation Trust

The Oxford Institute of Clinical Psychology Training and Research

UNIVERSITY OF OXFORD

Oxford Doctoral Course in Clinical Psychology
An NHS Course validated by the University of Oxford

Isis Education Centre, Warneford Hospital, Oxford OX3 7JX
Tel: +44(0)1865 226431
Website: www.oxicpt.co.uk

10 June 2019

To Whom It May Concern

Dear Sirs

Re: Confirmation of Funding Support – Veronika Kubickova , Trainee Clinical Psychologist

I can confirm that, Veronika Kubickova, Trainee Clinical Psychologist, has full support for her research dissertation project. Veronika has been allocated a budget to run her study and any costs incurred will be covered by the Oxford Institute of Clinical Psychology Training and Research.

Please let me know if there is any further information you require.

Yours sincerely

Tracy McAteer
Head of Operations

Senior Research / Academic Tutor:
Dr Myra Cooper, M.A. (Hons)., M.Phil., D.Phil., C.Psychol. Tel: (01865) 226375
myra.cooper@hmc.ox.ac.uk

RESEARCH SERVICES
Clinical Trials and Research Governance
Joint Research Office
Boundary Brook House
Churchill Drive
Headington, Oxford
OXON
OX3 7GB

To whom it may concern

Date: 18/07/2019

Dear Sir/Madam,

Title: Reducing Intrusive Memories of Work-Related Traumatic Events in Emergency Department Staff using a Simple Cognitive Task

PID: 14398

Protocol Date/Version: 18.07.2019 Version 1.0

The above study has been designed by Dr Craig Steel and colleagues at the University of Oxford and funded by the Oxford Doctoral Course in Clinical Psychology. I confirm that the University will accept the role of Research Sponsor of this Study and will comply with the requirements of the UK Policy Framework for Health and Social Care Research October 2017.

Insurance-provided indemnity arrangements are in place for the project:
Newline Underwriting Management Ltd., at Lloyd's of London.

Sponsorship is confirmed subject to the condition that the following are sent to Clinical Trials and Research Governance for review prior to submission to the Research Ethics Committee. Failure to do so may compromise insurance cover for the project.

- Any minor or substantial amendments
- Any extension to the study end date
- Addition of any new research site or patient identification centre

In addition, annual progress reports, the end of study notification and final report must be copied to Clinical Trials and Research Governance.

Lastly, where they exist, University Core SOPs must be followed by default for all clinical research sponsored by the University. Further information can be found here: https://researchsupport.admin.ox.ac.uk/ctrg/resources

Any communications relating to Research Sponsorship should be directed to the undersigned, whose contact details are given in this letter.

Yours faithfully

N. A. Wellman

Nigel Wellman
Clinical Trials and Research Governance

Tel: +44 (0)1865 616480 Web: https://researchsupport.admin.ox.ac.uk/ctrg
Email: Heather.house@admin.ox.ac.uk or Elaine.Chick@admin.ox.ac.uk

Professor Craig Steel
The Oxford Institute of Clinical Psychology Training and Research
Isis Education Centre
Warneford Hospital
Oxford
OX3 7JX

Email: hra.approval@nhs.net

22 October 2019 Dear Professor Steel

Study title:

IRAS project ID: Protocol number: Sponsor

Reducing Intrusive Memories of Work-Related Traumatic Events in Emergency Department Staff using a Simple Cognitive Task
266242
14398
University of Oxford / Clinical Trials and Research Governance

I am pleased to confirm that **HRA and Health and Care Research Wales (HCRW) Approval** has been given for the above referenced study, on the basis described in the application form, protocol, supporting documentation and any clarifications received. You should not expect to receive anything further relating to this application.

Please now work with participating NHS organisations to confirm capacity and capability, in line with the instructions provided in the "Information to support study set up" section towards the end of this letter.

How should I work with participating NHS/HSC organisations in Northern Ireland and Scotland?
HRA and HCRW Approval does not apply to NHS/HSC organisations within Northern Ireland and Scotland.

If you indicated in your IRAS form that you do have participating organisations in either of these devolved administrations, the final document set and the study wide governance report

(including this letter) have been sent to the coordinating centre of each participating nation. The relevant national coordinating function/s will contact you as appropriate.

Please see IRAS Help for information on working with NHS/HSC organisations in Northern Ireland and Scotland.

How should I work with participating non-NHS organisations?

HRA and HCRW Approval does not apply to non-NHS organisations. You should work with your non-NHS organisations to obtain local agreement in accordance with their procedures.

What are my notification responsibilities during the study?

The *"After HRA Approval – guidance for sponsors and investigators"* document on the HRA website gives detailed guidance on reporting expectations for studies with HRA and HCRW Approval, including:

- Registration of Research
- Notifying amendments
- Notifying the end of the study

The HRA website also provides guidance on these topics and is updated in the light of changes in reporting expectations or procedures.

Who should I contact for further information?

Please do not hesitate to contact me for assistance with this application. My contact details are below.

Your IRAS project ID is **266242**. Please quote this on all correspondence. Yours sincerely,

Gemma Oakes
Approvals Specialist
Email: hra.approval@nhs.net

MEDICAL SCIENCES INTERDIVISIONAL RESEARCH ETHICS COMMITTEE
Research Services, University of Oxford, Wellington Square, Oxford, OX1 2JD
Tel: +44(0)1865 616577 Fax: +44(0)1865 280467
ethics@medsci.ox.ac.uk

CONFIDENTIAL

Ref: R64738/RE001

Veronika Kubickova
Oxford Institute of Clinical Psychology Training & Research (OxICPT)
Isis Education Centre
Warneford Hospital
Oxford

30th September 2019

Dear Veronika,

Research Ethics Approval - CUREC 2

Study Title: Reducing Intrusive Memories of Work-Related Traumatic Events in Emergency Department Staff using a Simple Cognitive Task

Short Title: CALM-ED: Computer Assisted Lessening of intrusive Memories in the Emergency Department

The above application has been considered on behalf of the Medical Sciences Interdivisional Research Ethics Committee (IDREC) in accordance with the procedures laid down by the University for Ethical Approval of all research involving human participants.

I am pleased to inform you that, on the basis of the information provided to the IDREC, the proposed research has been judged as meeting appropriate ethical standards, and approval has been granted for a period of **17 months**, commencing on **30th September 2019**. The reference number for this study is **R64738/RE001**.

This is **subject to:**

a) **the PI agreeing to comply with the requirements for administering any tests or questionnaires and, if in doubt, to contact the publisher of those tests or questionnaires**

b) **the PI ensuring that, where new research staff are engaged, they are suitably qualified by training and/or experience**

I would like to remind you that you will be required to submit an annual progress report on each anniversary of study approval, until the study is completed, and that your study may be selected for review by the MS IDREC during an annual audit.

Amendments

Should there be any subsequent changes to the study, you should submit details to the MS IDREC for consideration and approval. Details of changes must be listed on an amendment form.

Please do not hesitate to contact me if you have any queries.

Yours Sincerely

H. Barnby-Porritt

Dr. Helen Barnby-Porritt
Research Ethics Manager, Medical Sciences

Oxford University Hospitals
NHS Foundation Trust
From the Head of Research Governance
OUH Research & Development
Joint Research Office
OUH Cowley

Tel: 01865 574420
Email: Debbie.Franklin@ouh.nhs.uk
Date: 04/11/2019

Confirmation of Trust Management Approval

Re: Reducing Intrusive Memories of Work-Related Traumatic Events in Emergency Department Staff using a Simple Cognitive Task
IRAS Reference: 266242
Research and Development Reference: 14398
Research Ethics Committee Reference:
NIHR Portfolio Ref: 43699
Sponsor: University of Oxford

Dear Dr Craig Steel,

On behalf of the Oxford University Hospitals NHS Foundation Trust, I am pleased to confirm Trust Management Approval and Indemnity for the above research as outlined in the application received.

Approved Documents

Protocol Version 1.0 dated 30.09.2019 is recognised as the most current to date.

The documents approved for use at this Trust are as listed in the following approval documents:

Health Research Authority Letter dated: 22/10/2019
Central University Research Ethics Committee letter date: 30/09/2019

Any subsequent, relevant amendments are additionally included to date.

Metrics and Recruitment

First Participant target	Agreed Total recruitment target
Target date:07/12/2019	Target minimum: 8
	Recruitment Target date 01/06/2020

To comply with national research performance requirements the OUH Trust will monitor and publish recruitment for your study:
1. Performance of the recruitment of the first participant to your study calculated from the time of receipt of a valid research application in R&D;

Signed electronically in Studyline by Dr Christopher Bray on 04/11/2019 16:57

2. Recruiting planned participants to time and target.

Recruitment of participants needs to be reported via the Siteline system. Contact your department Siteline administrator to request a userid. If you miss this target you will be required to give reasons that can be reported to the DOH/NIHR.

Study Staff
The CV and relevant training of the PI has been reviewed.

Conditions of Approval
The following conditions apply to this approval:

a) The study is conducted in compliance with all the relevant legislation and the relevant OUH policies.
b) All staff working on the study have the appropriate training and experience and have responsibilities formally delegated to them.
c) Serious Breaches of GCP or the protocol will be notified to the Head of Research Governance within one working day of awareness.
d) Should you plan to leave your position in OUH, you will notify R&D immediately of your plans, to enable discussions around the future of study conduct.
e) All relevant documents will be maintained and will be made available to R&D personnel, to facilitate compliance checks, formal audits and regulatory inspections..
f) You will notify R&D of any subsequent protocol amendments.
g) You will promptly inform R&D of the end of the study.

I wish you every success with the study.

Yours sincerely,



Dr Christopher Bray
Head of R&D Operations

Department / Location	Email
Trainee Clinical Psychologist	veronika.kubickova@hmc.ox.ac.uk
Emergency Research	Melanie.Darwent@ouh.nhs.uk Sally.Beer@ouh.nhs.uk

Signed electronically in Studyline by Dr Christopher Bray on 04/11/2019 16:57

Royal Berkshire
NHS Foundation Trust

Research & Development
Level 2, North Block
Royal Berkshire NHS Foundation Trust
London Road
Reading RG1 5AN

Tel: 0118 322 8223 / 8140
Fax: 0118 322 8425
jo.jones@royalberkshire.nhs.uk

Dr Liza Keating
Consultant
Urgent Care Department
Royal Berkshire NHS Foundation Trust
London Road
Reading
RG1 5AN

30 January 2020

Dear Dr Keating,

RE: CALM-ED: Reducing Intrusive Memories of Work-Related Traumatic Events in Emergency Department Staff using a Simple Cognitive Task/ Emergency Department
REC Ref: University of Oxford CUREC 2 Approval, R64738/RE001
EudraCT number: n/a
ISRCTN No: n/a
UKCRN: 43699
HRA: 266242
PID number: 14398
Protocol Version: 1, dated 30.09.2019

Capacity and capability to conduct this study at the Royal Berkshire NHS Foundation Trust is confirmed. A list of the letters containing documents reviewed is listed below.

Please also note that recruitment into the study is expected to start within 19 days of the date of this letter or by the date of 18/02/2020. If you foresee any issues with achieving this please do let R&D know.

As Principal Investigator, you have agreed to recruit 8 patients by the date of 01/05/2020 (recruitment end date).

As Principal Investigator, please may we remind you that R&D should be informed of any amendments to the Protocol, closure of the study or any changes made during the course of the study.

This study is on the National Institute for Health Research Clinical Research Network (NIHR CRN) portfolio and additional resources can be allocated to support the study, as appropriate. Hence, recruitment figures should also be sent to R&D every month from the start of the study until completion.

Should any problems arise with recruitment or any other aspects of the study, please do not hesitate to contact R&D on the above numbers.

We would also like to take this opportunity to remind you of your responsibilities under the UK Policy Framework for Health and Social Care Research. An extract from this framework outlining these responsibilities are included with this letter for your reference.

We wish you all the best with the study.

Yours sincerely,



Jo Jones
Clinical Research Facilitator

Cc – Carys Jones - Clinical Implementation Manager, RBFT
Nicola Jacques - Research Team Lead, RBFT

Sponsor – University of Oxford
Chief Investigator – Prof Craig Steel, Oxford Health NHS Foundation Trust
Studyline RBFT Database - royalberkshire@studyline.uk.com

Enclosure: Extract From UK Policy Framework for Health and Social Care Research (Version 3.3, 07/11/2017)
Responsibilities of Researcher, PI/CI, Funder and Sponsor
Organisation Information Document (OID)

Regulatory Approval letters listing approved documents:

- University of Oxford CUREC 2 Approval dated 30/09/2019
- HRA and Health and Care Research Wales (HCRW) Approval Letter dated 22/10/2019

South Central Ambulance Service NHS
NHS Foundation Trust

2nd July 2020

Veronika Kubickova
Oxford Institute of Clinical Psychology
Training and Research

By email: veronika.kubickova@hmc.ox.ac.uk

John Black, Medical Director
South Central Ambulance Service
NHS Foundation Trust
Northern House
7-8 Talisman Road
Bicester
OX26 6HR
Executive Assistant Penny Long
Tel: 01869365000 x 5161
Email: penny.long@scas.nhs.uk

Project title: Reducing Intrusive Memories of Work-Related Traumatic Events in Emergency Department Staff using a Simple Cognitive Task

Funding: Oxford Institute of Clinical Psychology Training and Research, Isis Education Centre, Warneford Hospital, Headington, Oxford, OX3 7JX

The John Fell Fund, University of Oxford, Oxford University Innovation, Buxton Court, 3 West Way, Oxford, OX2 0JB

IRAS Project ID: 266242

Sponsor: Clinical Trials and Research Governance (CTRG), Research Services, University of Oxford, Joint Research Office, Boundary Brook House, Churchill Drive, Oxford, OX3 7GB

We are pleased to inform you that South Central Ambulance Service NHS Foundation Trust has given research governance approval for Trust Staff to participate in the above study.

The following documents were received:

Document	Version	Date
CALM ED Research Protocol	V1.4	16/04/2020
CALM ED CRG Template	V3.0	22/06/2020
CTRG(Sponsor) approval email Amendment to CALM_ED minor amendment 4 (15042020) IRAS ID 26624	V1.0	21/05/2020
CALM ED Poster	V1.0	
CUREC Amendment form		20/05/2020
MSD Ethics committee approval email R64738RE004 Reducing Intrusive Memories of Work-Related Traumatic..... - Amendment Approval		21/05/2020
SCAS risk assessment CALM ED		29/06/2020

Permission is granted on the understanding that there will be no deviation from the documents submitted.

Amendments

You should inform the Research Team before implementing any changes to the project.

We may contact you to request updates regarding progress with your project. In the meantime, should you experience any difficulties please contact our research administrator Sarah Taylor by email at sarah.taylor@scas.nhs.uk in the first instance.

We wish you every success with your project and look forward to seeing the results.

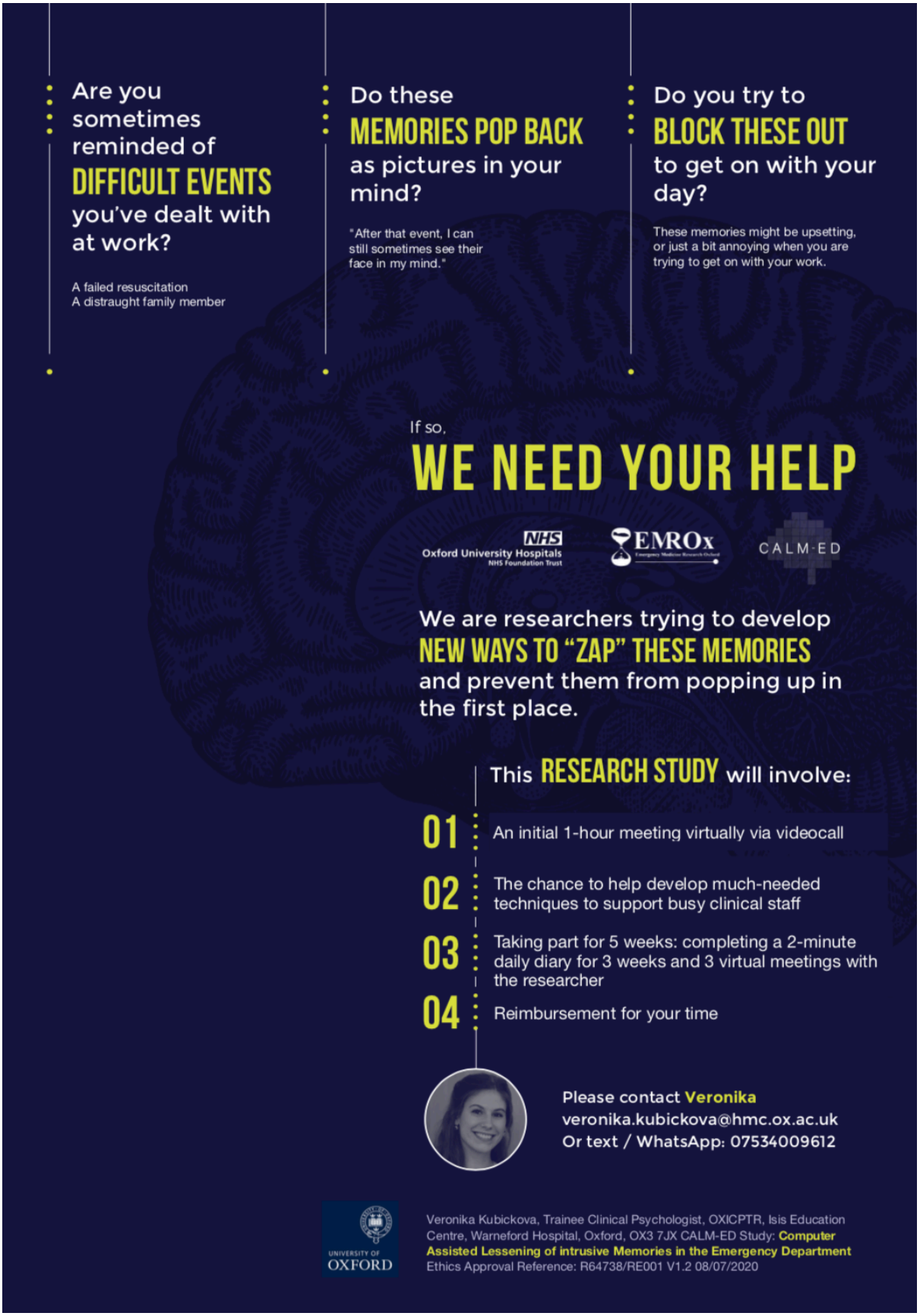
Yours sincerely

Sarah Taylor

pp John Black

Medical Director/Chair of Clinical Review Group

Appendix 20: Sample recruitment material: study poster and recruitment email



Recruitment email for the study

"CALM-ED: Computer Assisted Lessening of intrusive Memories in the Emergency Department"

Emails will be distributed among front-line clinical staff.

Subject: **Are you an NHS clinical staff member? We need your help with our research study.

Dear colleagues,

Re: **"CALM-ED research study (Computer Assisted Lessening of intrusive Memories in the Emergency Department)"**

We would love to hear from you - nurses, doctors, paramedics, healthcare assistants - if you are experiencing **bothersome or upsetting memories of difficult clinical situations you have encountered at work**. This could be, for example, a failed resuscitation, of which images still pop into your mind (e.g. of the person's face).

This is more relevant now, during the Covid-19 pandemic, than ever, given the daily challenges we are all are exposed to.

Having intrusive memories is extremely common (approximately 65% of front line staff have them) but we don't often talk about them or their impact on us.

We are testing a simple cognitive intervention to reduce intrusive traumatic memories. This has been tested in several other populations. We would now like to see if it can help frontline staff too.

Due to Covid-19, all contact between participants and the researcher will be done remotely (e.g., Zoom/MS Teams), including the delivery of the intervention. The study includes:

- Participation for a total of 5 weeks
- An initial meeting with the researcher to assess eligibility for the study
- A brief intervention including playing a simple computer game
- Recording your intrusive memories in a 2-minute daily electronic diary for 3 weeks
- A £50 reimbursement for participation

All clinical staff are eligible.

If you or any of your colleagues are experiencing work-related intrusive memories, please get in touch or pass on my contact details:

veronika.kubickova@hmc.ox.ac.uk

0753 400 9612.

I will be happy to explain more about the study.

Thank you very much for your help. I hope you and your families are keeping as well as possible.

Appendix 20: Participant Information sheet

Oxford Institute of Clinical Psychology Training and Research (OXICPTR)
Isis Education Centre
Warneford Hospital
Headington
Oxford
OX3 7JX

PARTICIPANT INFORMATION SHEET (Version 1.4 08/07/2020)

Study Title: CALM-ED: Computer Assisted Lessening of intrusive Memories in the Emergency Department
Principal Investigator: Prof Craig Steel
Other Investigators: Dr Lalitha Iyadurai
Student Researcher: Veronika Kubickova
IRAS Reference Number: 266242

Introduction

You are being invited to take part in a research study. Before you decide, it is important that you understand why the research is being done and what it will involve. Please take time to read this information and discuss it with others, if you wish. If there is anything that is not clear, or if you would like more information, please ask us.

What is the purpose of the study?

As staff working in NHS hospital and pre-hospital departments during the Covid-19 pandemic, you may be faced with upsetting clinical situations. As a result, it is not unusual to experience distressing intrusive memories of these incidents. Intrusive memories are vivid, emotional memories of the incident that pop into your mind without warning. They often take the form of visual pictures in your mind's eye e.g. like a snapshot image or a film clip but can also include other senses e.g. sounds and smells. They may or may not be triggered by something you are aware of e.g. telling someone about the incident, being back at the scene. Intrusive memories can be very short, fleeting and broken up. They can also temporarily affect your ability to do your job.

There is currently very little support to help manage these intrusive memories.

We are carrying out research to examine whether a simple procedure including playing a computer game *Tetris* helps to reduce the number of intrusive memories and other symptoms

after being exposed to hospital traumatic events. We hope that this research will lead to the development of new interventions for front-line staff who experience work-related trauma in the future.

Who can take part?

We are looking for 8 – 20 clinical staff members (e.g. nurses, doctors, paramedics, HCA's) working in hospital and pre-hospital departments who are currently experiencing intrusive memories of work-related incidents, which are problematic to them. To be able to take part, we would like you to:

- Be above the age of 18
- Be able to read, write and speak in English
- Be able and willing to provide informed consent and complete study procedures
- Be a clinical NHS staff member working in hospital/pre-hospital departments (e.g. nurse, doctor, HCA)
- Be having intrusive memories, which are problematic to you
- Be having at least two intrusive memories per week of a work-related traumatic incident
- Be able and willing to talk about your intrusive memories
- Be able and willing to complete a daily electronic diary for 2-3 weeks (takes about 2 minutes to complete)
- Be able and willing to play the computer-game *Tetris* on a hand-held device for 25 minutes
- Be able and willing to complete four questionnaires at five time points (take about 10 minutes to complete)
- Not be currently undergoing treatment for PTSD or its symptoms

Do I have to take part?

No – it is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and will be asked to provide verbal consent. You will still be free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect your employment with the Trust in any way.

What will happen to me if I decide to take part?

In light of the Covid-19 pandemic, and face-to-face contact with participants being restricted, all meetings with the researcher will take place remotely via a video call or telephone. These meetings will take place in your personal (not work) time.

1) *First meeting with the researcher (approximately one hour long)*

- This first meeting is called the Eligibility and Baseline Assessment meeting. The date of this meeting will be arranged between yourself and the researcher and will be on a day and time that suits you.
- At this meeting we will check whether you are eligible to participate, by going through the inclusion criteria with you.

- If you are eligible and would like to continue, we will enrol you into the study and we will collect some personal information, such as contact details, and demographic information.
- During the Baseline part of the assessment, we will ask you some questions about the intrusive memories you are experiencing, including a brief description of their content, how many you are having, and identifying the intrusive memory which you would like to target with the intervention.
- You will then be asked to complete five questionnaires about your mood, sleep and intrusive memories. This will take approximately 15 minutes.
- You will be asked to 'meet' via video call/telephone with the researcher in 1-weeks' time for an intervention session.
- You will be asked to complete a daily electronic Intrusion Diary, which takes about 2 minutes to fill out, and weekly questionnaires for 3 weeks, which take about 10 minutes to complete. This can be done at a time most convenient to you.

2) *Simple computer-game intervention* session *(approximately one hour long)*

The intervention procedure will take place about 1 week after the initial meeting.

The intervention procedure will involve:

- Writing a short excerpt of the traumatic event, which the researcher does not need to see, and you can shred afterwards.
- You will then be asked to play a computer game *Tetris* for 25 minutes without interruption.
- You will also have the option to complete intervention boosters during your daily life. These can either be self-administered and/or researcher assisted.

3) *Other points of contact with the researcher during the 5-week period*

- The researcher would like to keep in contact with you throughout the study e.g. by sending you daily text message reminders to complete the electronic Intrusion Diary, and through weekly email/phone contact as helpful.

4) *1-month follow-up meeting with the researcher via video call or telephone (approximately 30 minutes long)*

This will involve the following:

- Debriefing you about the study and answering any questions.
- Completing five questionnaires
- Completing a Feedback questionnaire
- Reimbursing you for your time

Please note:

- You can decide to stop participating at any point.
- You need not answer questions that you do not wish to.
- Anything you tell us will be confidential. Your name will be removed from the information and it will not be possible to identify anyone from our reports on the study.

What are the possible disadvantages or risks of taking part?

We will ask you to talk about your intrusive memories of distressing clinical events, and to write down a description of this/these event(s), which some people may find upsetting. If you do find this upsetting you may stop the study at any time without having to give a reason, and

you would not have to answer any questions that you did not want to. At the start of the study, you will be signposted to appropriate services to access help if necessary. You will also be advised to seek help if you indicate that you could pose a risk to others.

What are the possible benefits of taking part?

We hope that by participating in the study, the number of intrusive memories will be reduced, however we do not yet know what the outcome of the study will be. You will also be contributing to the development of novel interventions to help front-line staff members, like yourself, to manage distressing work-related incidents in the future.

Would information collected about me during this study be kept confidential?

Your taking part in the study will be kept confidential, as will all information that is collected about you during the research. The information will be accessible only to the research team and authorised parties (see below) and will be handled in confidence. The information available to other study researchers include the collected demographic and employment data. Results of the study may also be made available to other researchers but only through a protected database after removing all information that would identify you. All research data will be assigned a number and will be stored without your name on them. All identifiable information, for example your demographic information, will be securely stored on University of Oxford computers and on password-protected IBM SPSS Statistics software documents. Data recorded on Qualtrics software (i.e. all data entered online to which a link is provided) is stored on the Qualtrics European data server. You will only ever be entering data under your assigned participant number. If you decide to withdraw from the study part way through, we will not collect any further information from you, but will keep any information we have already collected in a de-identified form until the end of the study. We may ask your permission to quote something you have said word for word in a publication arising from this study. However, we will only ever use quotes which you permit us to use. Any potentially identifying data in quotes will be removed or disguised.

If you experience high levels of distress or suicidal ideation throughout the study, you will be advised to seek help (in line with the provided signposting information) and we may wish to inform your GP or emergency services. However, we would discuss this with you first and would only disclose information of immediate relevance. We are not obliged to inform your employer or manager of any of these details.

If at any point during the study you reveal information that may suggest professional malpractice, you will be encouraged by the researcher to report this to the Hospital's Freedom To Speak Up (FTSU) Guardian and/or to follow the Trust Whistleblowing Policy. However, if you do not feel able to do so, the researcher has an obligation to report it on your behalf.

Responsible members of the University of Oxford, the Oxford University Hospitals NHS Trust, Royal Berkshire NHS Foundation Trust or South Central Ambulance Service NHS Foundation Trust may be given access to data for monitoring and/or audit of the study to ensure that the research is complying with applicable regulations. All will have a duty of confidentiality to you as a research participant and nothing that could reveal your identity would be disclosed outside of the research team.

What will happen to my data?

Data protection regulation requires that we state the legal basis for processing information about you. In the case of research, this is 'a task in the public interest.' The University of

Oxford is the data controller and is responsible for looking after your information and using it properly. We will be using information from you in order to undertake this study and will use the minimum personally-identifiable information possible. We will keep identifiable information about you for a maximum of 6 months after the study has finished. We will store the de-identified research data and signed consent forms securely at the University of Oxford for 3 years after the end of the study. After this time all data will be destroyed. With your permission however, your contact details can be kept for future studies.

Data protection regulation provides you with control over your personal data and how it is used. When you agree to your information being used in research, however, some of those rights may be limited in order for the research to be reliable and accurate. Further information about your rights with respect to your personal data is available at http://www.admin.ox.ac.uk/councilsec/compliance/gdpr/individualrights/]
You can find out more about how we use your information by contacting Veronika Kubickova, tel: 01865 226 431; 07534009612, email: veronika.kubickova@hmc.ox.ac.uk.

What if something goes wrong?

Any complaint about the way you have been dealt with during the study or any possible harm you might suffer will be addressed. If you wish to complain about any aspect of the way in which you have been approached or treated, or how your information is handled during the course of this study, you should contact the Investigator for the project: Veronika Kubickova, Oxford Institute of Clinical Psychology Training, Isis Education Centre, Warneford Hospital, Headington, Oxford, OX3 7JX, tel: 01865 226 431; 07534009612, email: veronika.kubickova@hmc.ox.ac.uk or you may contact the University of Oxford Clinical Trials and Research Governance (CTRG) office on 01865 616480, or the head of CTRG, email ctrg@admin.ox.ac.uk.
Given the nature of this study, it is highly unlikely that you will suffer harm by taking part. However, the University of Oxford, as Sponsor, has appropriate insurance in place in the unlikely event that you suffer any harm as a direct consequence of your participation in this study.

Will I be reimbursed for taking part?

Yes - to thank you for completing the study, we will give you a £50 reimbursement, either as an Amazon voucher or using bank transfer, depending on your preference. If you withdraw from the study anytime during weeks one to two of the study period, you will be reimbursed £25 and if you withdraw from the study anytime during weeks three to five you will be reimbursed the full amount of £50. You will also be reimbursed for your travel to and from the hospital on days when you meet with the research.

What would happen to the results of the research?

The results of the research will be written up for publication in scientific journals and will contribute towards Veronika Kubickova's doctoral thesis. Any research publication would not identify you individually. You will have access to the results as we will email a link to the published study to the clinical staff. The results may be made available to other researchers but only through a protected database after removing all information that identifies individuals.

How have the public been involved in this study?

Members of ED staff have been involved in:

- *Reviewing the Participant Information Sheet, Consent Form and advertising material.*
- *Piloting the Intrusion Diary.*
- *Advising on the feasibility of the study procedures.*

Who is organising and funding the study?

The study is sponsored by the University of Oxford. It is funded by the Oxford Institute of Clinical Psychology Training and the University of Oxford John Fell Fund.

Who has reviewed the study?

This study has been reviewed and given favourable opinion by University of Oxford Medical Sciences Interdivisional Research Ethics Committee (MS IDREC).
Research Ethics Committee.

Contact for further information

If you have any further questions about this research, please feel free to speak to:
Veronika Kubickova (Trainee Clinical Psychologist)
tel: 01865 226 431; 07534009612
e-mail: veronika.kubickova@hmc.ox.ac.uk
Dr Lalitha Iyadurai (Clinical Psychologist and External Supervisor of this study)
tel: 01865 613117
e-mail: lalitha.iyadurai@psych.ox.ac.uk
Professor Craig Steel (Deputy Director at OXICPT and Internal Supervisor of this study)
tel: 01865226366
e-mail: craig.steel@hmc.ox.ac.uk.

Thank you for taking the time to read this information sheet and considering whether to take part in this research.

If you have considered the information above and would like to take part in the study, please carefully read through the consent form (provided as an email attachment) and electronically return to the researcher.

Appendix 22: Verbal consent form

Oxford Institute of Clinical Psychology Training and Research (OXICPTR)
Isis Education Centre
Warneford Hospital
Headington
Oxford
OX3 7JX

VERBAL CONSENT FORM (Version 1.3 16/04/2020)

Study Title: CALM-ED: Computer Assisted Lessening of Intrusive Memories in the Emergency Department
Principal Investigator: Prof Craig Steel
Other Investigators: Dr Lalitha Iyadurai
Student Researcher: Veronika Kubickova
IRAS Reference Number: 266242

Researcher to seek and record informed oral consent, after participant has had sufficient time to think about whether they want to take part.

Please check the boxes to record that the statement has been asked by the researcher and that the participant has responded in the affirmative:

Have you read the information sheet dated 16/04/2020 (Version 1.3) for this study, had the opportunity to consider the information, ask questions and have these answered satisfactorily? ☐

Do you understand that your participation is voluntary and that you are free to withdraw at any time, without giving any reason, without your employment rights being affected? ☐

Are you aware that the demographic and employment data that you provide during the Screening and Eligibility assessment will be available to the study researchers? ☐

Are you aware that all information will be kept strictly confidential, except in the rare circumstances in which it is judged that you or someone else is at current risk of serious harm, in which case my GP or other named health professional will be informed? ☐

Are you aware that if the researcher deems you to be at risk to yourself or others during the period of the study, you will be advised to seek help (in line with the signposting information provided at the start of the study)? If the researcher deems you to be at *immediate* risk to yourself or others and you do not wish to contact the appropriate services (e.g. my GP or emergency services), they will be contacted on your behalf, even without your consent. ☐

Do you understand that data collected during the study may be looked at by individuals from University of Oxford, from regulatory authorities, and from the Oxford Universities Hospitals NHS Foundation Trust or Royal Berkshire NHS Foundation Trust, where it is relevant to your taking part in this research? Do you give permission for these individuals to have access to your research records? ☐

Are you aware that the results may be made available to other researchers but only through a protected database after removing all information that identifies individuals? ☐

Do you agree to the use of anonymised quotes in research reports and publications? ☐

I agree to take part in the above study. ☐

	YES	NO
[*Optional*] Are you willing to be contacted by the research team about future research studies after the study has finished? Agreeing to be contacted does not oblige you to participate in any further studies	☐	☐

Name of Participant

Name of Researcher taking consent Date Signature

_____ _____ _____

Original for research site; copy to be emailed to participant

Appendix 23: Signposting Information sheet

Oxford Institute of Clinical
Psychology Training and
Research (OXICPTR)
Isis Education Centre
Warneford Hospital
Headington
Oxford
OX3 7JX

The CALM-ED research team have put together a list of resources and services which you can access if you are feeling distressed or upset by the intrusive memories or other symptoms related to the hospital traumatic events.

Trust and GP Resources

If you feel able to, you can speak to your **line manager** at work about the difficulties you are experiencing. They can provide further advice and support in helping you manage these or point you in the direction of someone who can help.

If you are struggling emotionally following a hospital traumatic event and/or if at any point life feels as though it's not worth living, **please contact your GP** who will be able to provide further support.
You can contact the **Trust Occupational Health Services** for all workplace health concerns. Who to contact will differ depending on if you are a JRH or RBH employee:

Royal Berkshire NHS Foundation Trust (RBH Staff)
Occupational Health Department
21 Craven Road
Reading
RG1 5AN
Tel: 0118 322 7634
Email: occhealth.reception@royalberkshire.nhs.uk

Oxford University Hospitals NHS Foundation Trust (JRH Staff)
Occupational Health Department
Centre for Occupational Health and Wellbeing
John Radcliffe Hospital
Headley Way
Headington
Oxford
OX3 9DU
Tel: **01865 223325**
Email: OccupationalHealthJR@ouh.nhs.uk
Employee Assistance Programme is offered as a benefit to OUH staff. Staff here can help you with a range of personal issues that might adversely impact your work performance, health and well-being. It's free to use, available 24 hours a day, seven days a week, 365 days a year.
Freephone: 0800 243 458
Email assistance@workplaceoptions.com

)

South Central Ambulance Service (SCAS) specific resources

Trauma Risk Management (TriM)
SCAS has trained members of staff ranging from Emergency Care assistants to Managers who are able to have 1:1 assessments with staff who have experienced a traumatic event at home or at work which they were directly involved in. TRiM forms part of the welfare process for such staff and provides on-going support, further referral and guidance.
Email: TRimCo-ordinators@scas.nhs.uk

Employee Assistance Programme (Optum)
The Trust provides an Employee Assistance Programme (EAP) called Optum. This is a prepaid 24-hour service available to all staff and their immediate family. The EAP provides a completely independent, confidential and off-site professional counselling and referral service, as well as information regarding legal, financial and Citizens Advice Bureau services.
Telephone: 0800 282 193
Website: https://livewell.optum.com/public/welcome.asp

Occupational Health (Team Prevent)
You may self-refer to occupational health for advice on your health concerns.

Occupational Health may be able to support early intervention in the management of health problems adversely affecting your work attendance or performance and can help you return to work quicker.

Telephone: 01327 810 797
Website:
https://eopas.teamprevent.co.uk/genohsisportal/login.aspx?ReturnUrl=%2fgenohsisportal%2fGenohsis_Portal.aspx

Talking Therapies (IAPT)

Problems such as anxiety, depression, stress and phobias are very common. **Talking Therapies** is a friendly and approachable free NHS service that helps people with these problems. Please see the contact details for two Talking Therapies services helping people in Oxfordshire and Berkshire.

You can self-refer yourself to these services by accessing the Talking Therapies website or by telephone. If you telephone, you will speak to an Administrator who will take your details (including your name, address, date of birth, registered GP) and book a telephone appointment with a member of their team.

Your GP or other healthcare professionals can also refer you to Talking Therapies. Speak to them if you would like to get referred.

Talking Therapies Berkshire

Working with NHS Berkshire Healthcare NHS Foundation Trust

Contacting Talking Therapies Berkshire:

Telephone: 0300 365 2000
Email: talkingtherapies@berkshire.nhs.uk
A self-referral form on their website:
https://www.talkingtherapies.berkshire.nhs.uk/page_sa.asp?fldKey=217

TalkingSpace Plus Oxfordshire

TalkingSpace PLUS NHS Oxford Health NHS Foundation Trust

Contacting TalkingSpace Plus:
Telephone: 01865 901 222
A self-referral form on their website:
https://www.oxfordhealth.nhs.uk/talkingspaceplus/contact/

Samaritans

Samaritans is a registered charity aimed at providing emotional support to anyone in emotional distress, struggling to cope, or at risk of suicide.



Please inform the researcher, Veronika Kubickova (tel: 07534009612; email: veronika.kubickova@hmc.ox.ac.uk), if you decide to start treatment for post-traumatic stress disorder or any of its symptoms, including intrusive memories, **whilst involved in the study** as this may affect your ability to continue taking part.

The signposting information has been agreed by emergency department managers and is in accordance with the University of Oxford CUREC (Ethics Committee) Best Practice Guidelines.

Appendix 24: Participant personal information form

Oxford Institute of Clinical
Psychology Training and
Research (OXICPTR)
Isis Education Centre
Warneford Hospital
Headington
Oxford
OX3 7JX

PARTICIPANT PERSONAL INFORMATION FORM

(V1.1 08/07/2020)

First Name

Last Name

Work Email Address

Mobile Phone Number

GP Details

Bank Details (if participant wishes to be reimbursed by bank transfer

Participant ID Number

Are you happy to receive daily text messages reminding you to complete the daily Intrusion Diary?

☐ Yes ☐ No

Signed

Dated

Appendix 25: Tau-*U* analysis output

id	Label	S	PAIRS	TAU	TAUb	VARs	SD	SDtau	Z	P Value	CI 85%	CI 90%
trend:												
0	P1B vs P1B	-15	231	-0.0649	-0.0843	1257.667	35.4636	0.1535	-0.423	0.6723	-0.286<>0.156	-0.317<>0.188
7	P3B vs P3B	-8	28	-0.2857	-0.3077	65.3333	8.0829	0.2887	-0.9897	0.3223	-0.701<>0.130	-0.761<>0.189
8	P4B vs P4B	-7	28	-0.25	-0.2857	65.3333	8.0829	0.2887	-0.866	0.3865	-0.666<>0.166	-0.725<>0.225
15	P5B vs P5B	1	45	0.0222	0.0256	125	11.1803	0.2485	0.0894	0.9287	-0.336<>0.380	-0.386<>0.431
19	P7B vs P7B	3	36	0.0833	0.0923	92	9.5917	0.2664	0.3128	0.7545	-0.300<>0.467	-0.355<>0.522
21	P8B vs P8B	-5	28	-0.1786	-0.2041	65.3333	8.0829	0.2887	-0.6186	0.5362	-0.594<>0.237	-0.653<>0.296
23	P9B vs P9B	5	28	0.1786	0.2439	65.3333	8.0829	0.2887	0.6186	0.5362	-0.237<>0.594	-0.296<>0.653
25	P10B vs P10B	-3	21	-0.1429	-0.15	44.3333	6.6583	0.3171	-0.4506	0.6523	-0.599<>0.314	-0.664<>0.379
27	P11B vs P11B	-5	28	-0.1786	-0.2222	65.3333	8.0829	0.2887	-0.6186	0.5362	-0.594<>0.237	-0.653<>0.296

29	P12B vs P12B	9	28	0.3214	0.3673	65.3333	8.0829	0.2887	1.1135	0.2655	-0.094<>0.737	-0.153<>0.796
31	P13B vs P13B	-1	28	-0.0357	-0.0392	65.3333	8.0829	0.2887	-0.1237	0.9015	-0.451<>0.380	-0.511<>0.439
33	P14B vs P14B	1	21	0.0476	0.0556	44.3333	6.6583	0.3171	0.1502	0.8806	-0.409<>0.504	-0.474<>0.569
36	P2B vs P2B	-131	300	-0.4367	-0.4755	1833.333	42.8174	0.1427	-3.0595	0.0022	-0.642<>-0.231	-0.671<>-0.202
38	P6B vs P6B	-8	36	-0.2222	-0.2857	92	9.5917	0.2664	-0.8341	0.4042	-0.606<>0.161	-0.661<>0.216
phase:												
39	P6B vs P6I	-39	117	-0.3333	-0.5	897	29.95	0.256	-1.3022	0.1929	-0.702<>0.035	-0.754<>0.088
40	P1B vs P1I	-138	440	-0.3136	-0.4381	6306.667	79.4145	-0.3136	-1.7377	0.0823	-0.574<>-0.054	-0.611<>-0.017
41	P3B vs P3I	-43	112	-0.3839	-0.4279	858.6667	29.303	0.2616	-1.4674	0.1423	-0.761<>-0.007	-0.814<>0.046
42	P4B vs P4I	-50	112	-0.4464	-0.5882	858.6667	29.303	0.2616	-1.7063	0.088	-0.823<>-0.070	-0.877<>-0.016
43	P5B vs P5I	-42	120	-0.35	-0.4158	920	30.3315	0.2528	-1.3847	0.1661	-0.714<>0.014	-0.766<>0.066
44	P7B vs P7I	-69	117	-0.5897	-0.6571	897	29.95	0.256	-2.3038	0.0212	-0.958<>-0.221	-1<>-0.169

45	P8B vs P8I	-55	112	-0.4911	-0.5946	858.6667	29.3033	0.2616	-1.8769	0.0605	-0.868<>-0.114	-0.921<>-0.061
46	P9B vs P9I	-14	112	-0.125	-0.1867	858.6667	29.3033	0.2616	-0.4778	0.6328	-0.502<>0.252	-0.555<>0.305
47	P10B vs P10I	-73	105	-0.6952	-0.7228	805	28.3725	0.2702	-2.5729	0.0101	-1<>-0.306	-1<>-0.251
48	P11B vs P11I	-4	112	-0.0357	-0.0471	858.6667	29.3033	0.2616	-0.1365	0.8914	-0.412<>0.341	-0.466<>0.395
49	P12B vs P12I	-73	112	-0.6518	-0.7192	858.6667	29.3033	0.2616	-2.4912	0.0127	-1<>-0.275	-1<>-0.221
50	P13B vs P13I	-10	112	-0.0893	-0.1042	858.6667	29.3033	0.2616	-0.3413	0.7329	-0.466<>0.287	-0.520<>0.341
51	P14B vs P14I	-39	105	-0.3714	-0.4643	805	28.3725	0.2702	-1.3746	0.1693	-0.761<>0.018	-0.816<>0.073
corrected baseline:												
13	P2B vs P2I	-360	748	-0.4813	-0.5275	14212	119.2141	0.1594	-3.0198	0.0025	-0.711<>-0.252	-0.743<>-0.219
Aggregated single ominibus effect size:												
Label	Tau	Var-Tau	Z	P-Value	CI 85%	CI 90%	CI 95%					
#39+#40+#41+#42+#43+#44+#45+#46+#47+#48+#49+#50+#51+#13	-0.3844	0.0669	-5.7423	0	-0.4807<>-0.2880	-0.4945<>-0.2743	TRUE					

Appendix 26: Pre-intervention stability assessment for secondary outcome measures

The stability of the pre-intervention period for each outcome measure was assessed using paired samples *t*-tests comparing first session with final pre-intervention scores, and changes on the IES-R, IES-R intrusion subscale[17], PHQ-9 and GAD-7 from the blocked (mean of first and second outcome measure scores)[18] pre-intervention period to the final session scores, were tested for *statistical significance* using paired samples *t*-tests, or Wilcoxon-signed rank tests (for outcome data that were not normally distributed).

Table A25. Statistical stability assessment of the pre-intervention period and statistical analysis of blocked pre-intervention v. final session scores (n = 14).

	First session	Final pre-intervention	Blocked pre-intervention	Final session		Effect size	
Baseline stability assessment	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Analysis	*d*	95% CI for *d*
IES-R total	40.86 (14.57)	32.14 (15.12)			$t(13) = 4.17$, $p = .001$*	1.11	0.43, 1.78
IES-R Intrusion subscale	17.21 (5.81)	14.14 (5.75)			$t(13) = 2.33$, $p = .037$*	0.62	0.04, 1.19
PHQ-9	9.71 (7.29)	7.86 (5.61)			$t(13) = 2.25$, $p = .042$*	0.60	0.02, 1.16
GAD-7	7.93 (5.66)	6.93 (4.30)			$t(13) = 1.53$, $p = .151$	0.41	-0.15, 0.95
Blocked baseline scores v. final session							
IES-R total			36.5 (14.24)	12.43 (11.84)	$Z = -3.30$, $p = .001$		
IES-R Intrusion subscale			15.64 (5.13)	5.64 (4.33)	$t(13) = 8.26$, $p < .001$	2.21	1.21, 3.19
PHQ-9			8.79 (6.32)	3.71 (3.79)	$t(13) = 4.53$, $p = .001$	1.21	0.50, 1.90
GAD-7			7.43 (4.87)	3.50 (4.16)	$Z = -2.98$, $p = .003$		

Note: A single asterisk represents statistically significant changes from first session to final baseline session, thus a lack of stability of the baseline period. Given the unstable baseline period, blocking of the first two pre-intervention scores was performed for each measure (including GAD-7, for consistency) to achieve a mean baseline score[19]. The blocked baseline score was compared with the final session score to analyse the statistical difference from baseline to post-intervention.

[17] The intrusion subscale of the IES-R was analysed in isolation as it represents the clinical measure of the hypothesised intervention target.

[18] When determining the blocked baseline period, first and second outcome measure scores were chosen for consistency, given the variability in baseline period lengths among participants.

[19] It was decided that blocking of the first two outcome measure scores would provide the most consistent approach across participants, given that P1 and P2 had longer baseline periods.

Appendix 27: Data accuracy check

Data checking summary

Data checked:

Intrusive Memory Diary data:

- number of intrusive memories (primary outcome)

- distress, vividness, concentration, task disruption, occurrence at work, length of time intrusive memories were bothersome for, sleep quality, accuracy ratings, intervention boosters (secondary and tertiary outcomes)

Rater description:

Jack Olivarius-McAllister (JOM) is a medical doctor with good knowledge of statistics. He is an independent rater and is not associated with the study.

Data checking outcome summary:

One hundred percent of primary outcome data (all intrusive memories for all participants on the intrusive memory diary) and one hundred percent of secondary outcome data from the intrusive memory diary for two participants (selected at random) was checked for accuracy by an independent rater. One error out of 367 data points (i.e., an 0.27% error rate) was identified among primary outcome data: the inclusion of an additional intrusive memory in the data analysis for P10. This intrusion was generated during an intervention session demonstration of the intrusive memory diary and erroneously incorporated into the final analysis. The error was rectified and analyses re-run. No errors (0% error rate) were identified among secondary outcome data checks for P7 and P11.

Table A27. Data accuracy checking process and outcome.

Date	Details of check	Outcome
05/12/2020	• Veronika Kubickova (VK) downloaded all participant's intrusive memories diaries from Qualtrics and saved them as Excel spreadsheets (anonymised as P1-P14, i.e., not using their original participant numbers), password-protecting them for security. • VK used an online random number generator (random.org) to generated two participants whose intrusive memory diary secondary and tertiary data would be checked in full. Participants 7 and 11 were selected at random. • JOM checked 100% of primary outcome data (number of intrusive memories) for accuracy, with regards to: o Data entry o Calculations of changes mean and % change in intrusive memory frequency from baseline and post-intervention. • JOM checked the intrusive memory diary secondary outcome data for P7 and P11 for accuracy, with regards to: o Data entry o Calculations of means and standard deviations of accuracy rating; % of intrusive memories which received a booster; % of intrusive memories occurring whilst at work; changes in intrusive memory characteristics and functioning from baseline to post-intervention.	• The error rate for primary data was 0.27%. One error out of 367 data points was identified among primary outcome data: the inclusion of an additional intrusive memory in the data analysis for P10. This impacted the consequent calculations, i.e., the change in targeted intrusive memory frequency. This was rectified by: o Removing the erroneously entered intrusive memory for P10 and re-analysing the changes in intrusive memory frequency. • No further errors were found in the calculations utilising intrusive memories for any of the fourteen participants. • No errors (0% error rate) were identified among secondary outcome data checks (data entry nor calculations) for P7 and P11. o Given the 0% error rate, no further secondary nor tertiary outcomes were checked.

Appendix 28: Themes of intrusive memory content

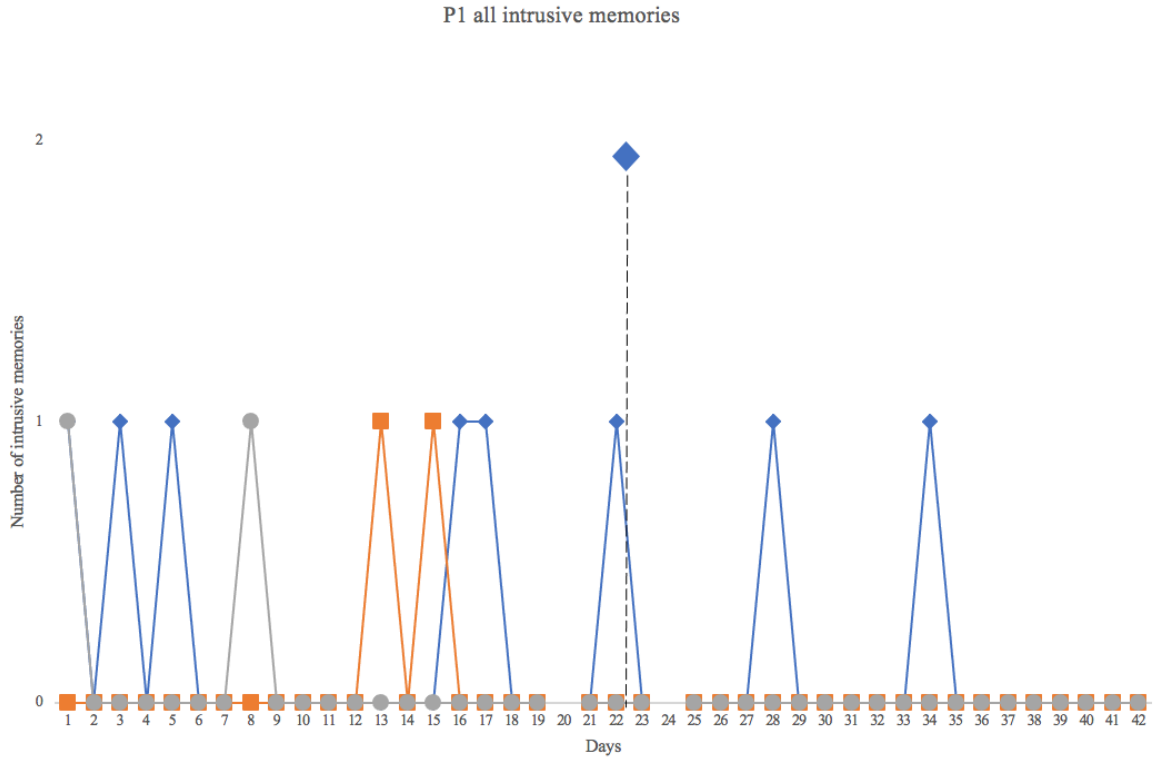
Table A28. Themes and examples of intrusive memories reported by participants (n = 14) in the list of intrusive memories questionnaire at Screening and Eligibility Assessment.
*Four out of five were part of the ambulance service team.

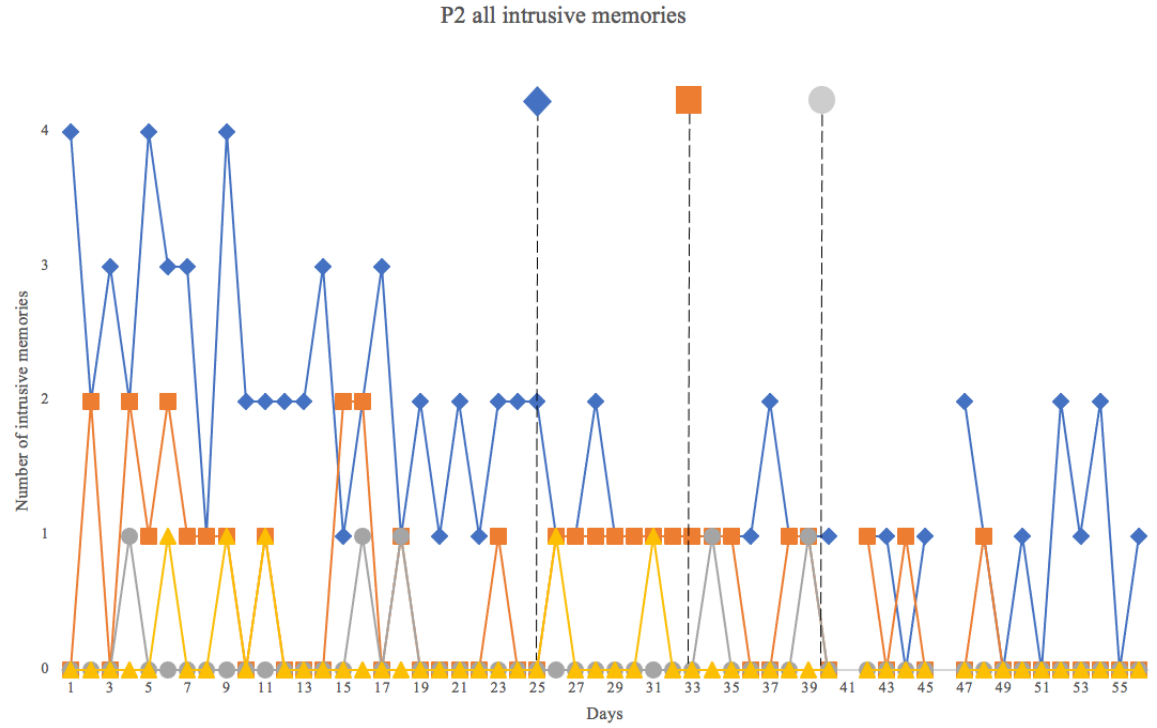
Common themes among intrusive memories	Number of participants for whom the theme featured in their intrusive memories	Examples of intrusive memories
Fatal injuries and/or witnessed death of babies, children and young people	9	"I see the bed space of a girl that died…I see her curly red hair." "I see the colour of what came out of the woman when cleaning her up. Grey, almost like tadpoles coming out of her." "The woman saying, "I've passed my baby."" "I see the image of the foetus on the screen looking like it's being decapitated." "I see a baby lying on a big trolley. The head was facing the wrong way." "Image of the boy hanging dressed entirely in black."
Witnessing death of others (excluding children)	11	"The patient laying on a driveway where they were flung onto. Blood running into the drain. A river of blood." "Seeing a man on the floor underneath the balcony and holding his jaw open." "Body with a blanket on top of it." "Seeing the patient wheeled away and seeing his head turned upwards." "Her in the car staring up."

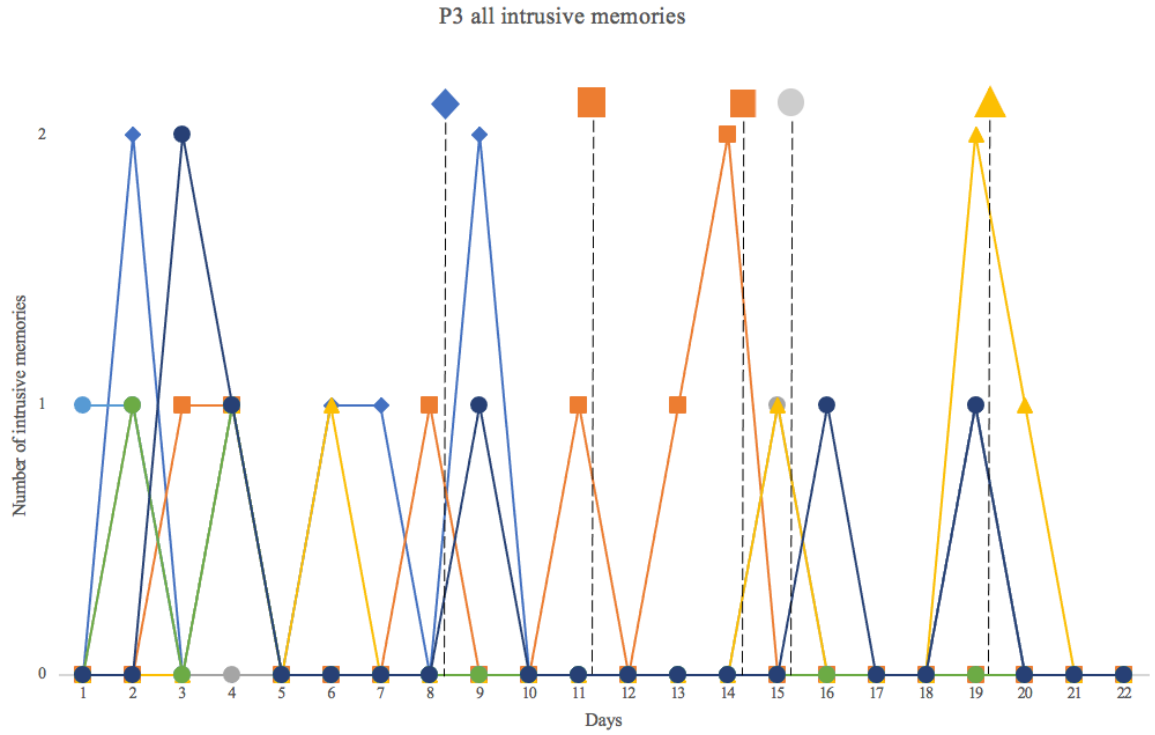
		"See the patient lying on the bed with the bag tied around their head."
"Seeing the person's face" – recognising and/or connecting with the emotion in the face of another	8	"The disgust in his face." "My colleagues face when seeing the baby, hearing her retching." "Seeing the woman's face when taking her hair off her face." "Seeing the worry in the face of the nurse in charge and hearing the phrase "you will take that baby."""
Threat to self/own life	5*	"Shutting the door on his [the assailant's] face." "Seeing the patient about to hit me." "Leading him towards the ambulance, myself walking back and him assaulting me." "Being sat bolt upright on the trolley. I see the team around me, being cannulated, consultant telling me not to leave them, seeing my legs and the wires over the top."
Witnessing high expressed emotion in others (screaming, crying)	8	"Hearing the mum screaming and crying when she was told the news." "Image of patient's daughter on the floor crying hysterically." "The dad actively dying and the children saying goodbye to him."
Absurdity of the situation which defies logic or learned rules about human and societal functioning	14	"Me standing at the side of the bed and the image of

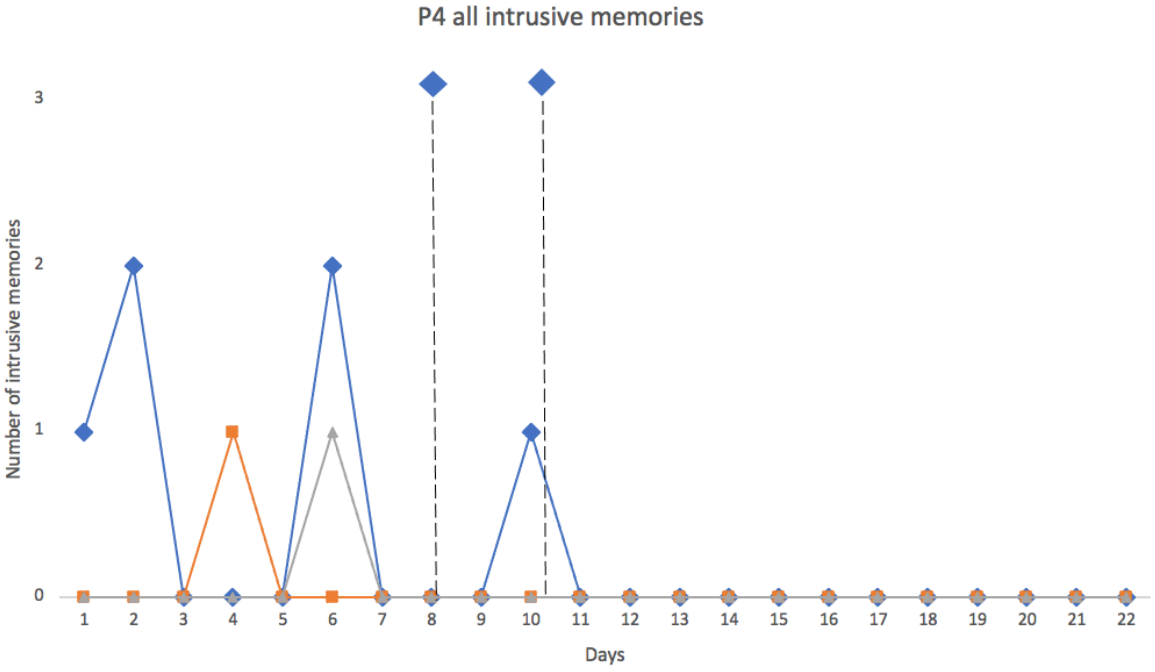
		the blood coming out of breathing tube.” “The car in the trees.” “Blood splatters all over the floor, on my apron and my hands” “I see a lorry parked diagonally across the motorway and the damage to the car.” “Limbs flexing outwards.”
Gruesome injuries / disfigurement of the human body	10	“Seeing a woman’s injuries and her on the ground after being hit by a lorry.” “Man on the ground covered in blood.” “Looking at the boy’s head and the brain was hanging out.” “Seeing bits of brain and tissue on the wall and stairs.” “Her stomach being so distended that you could see the bowel obstruction. Her skin had almost gone black over those areas.”
Carrying out a medical / nursing procedure	5	“Seeing myself climbing into the CT scanner and re-connecting the catheter.” “I see my hands squeezing saline into her.” “Seeing myself doing chest compressions.”

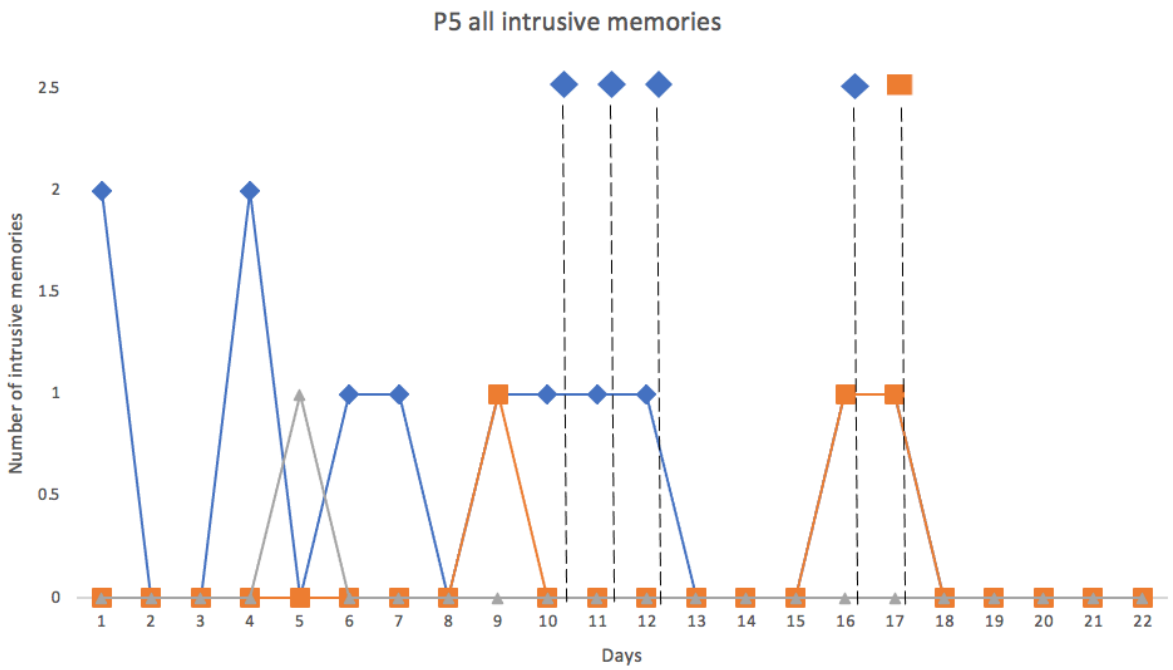
Appendix 29: Individual participant time course graphs

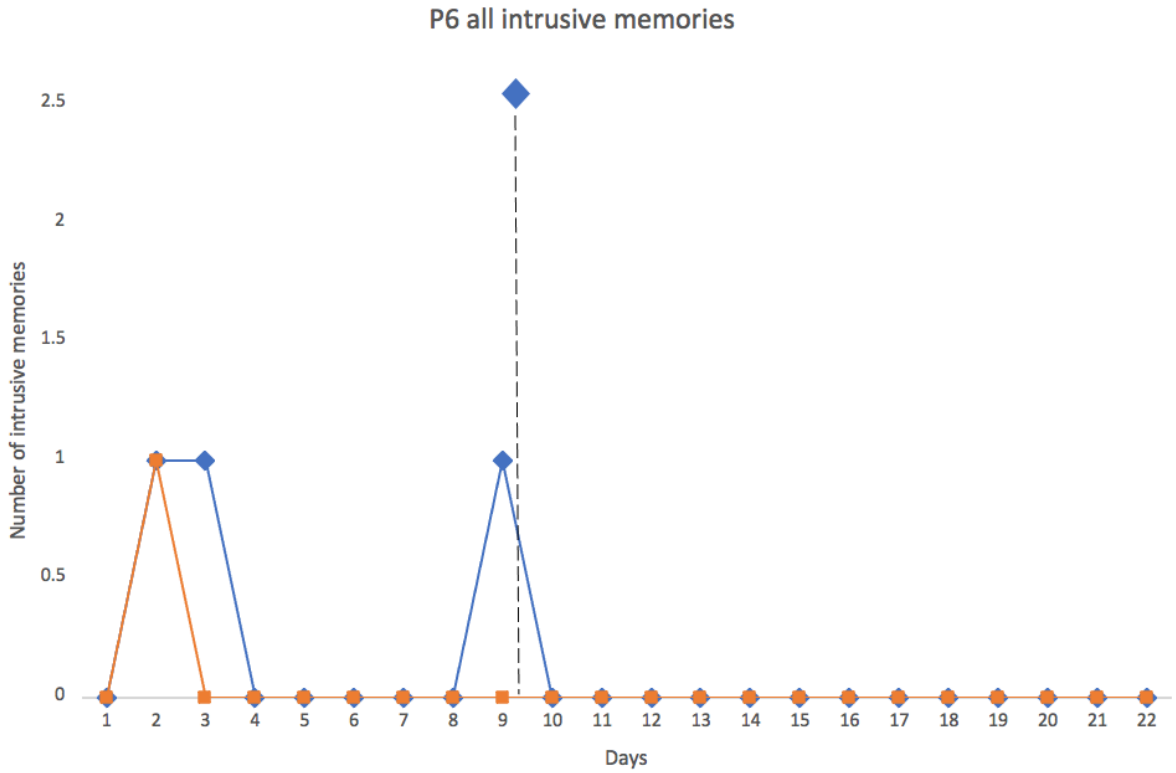


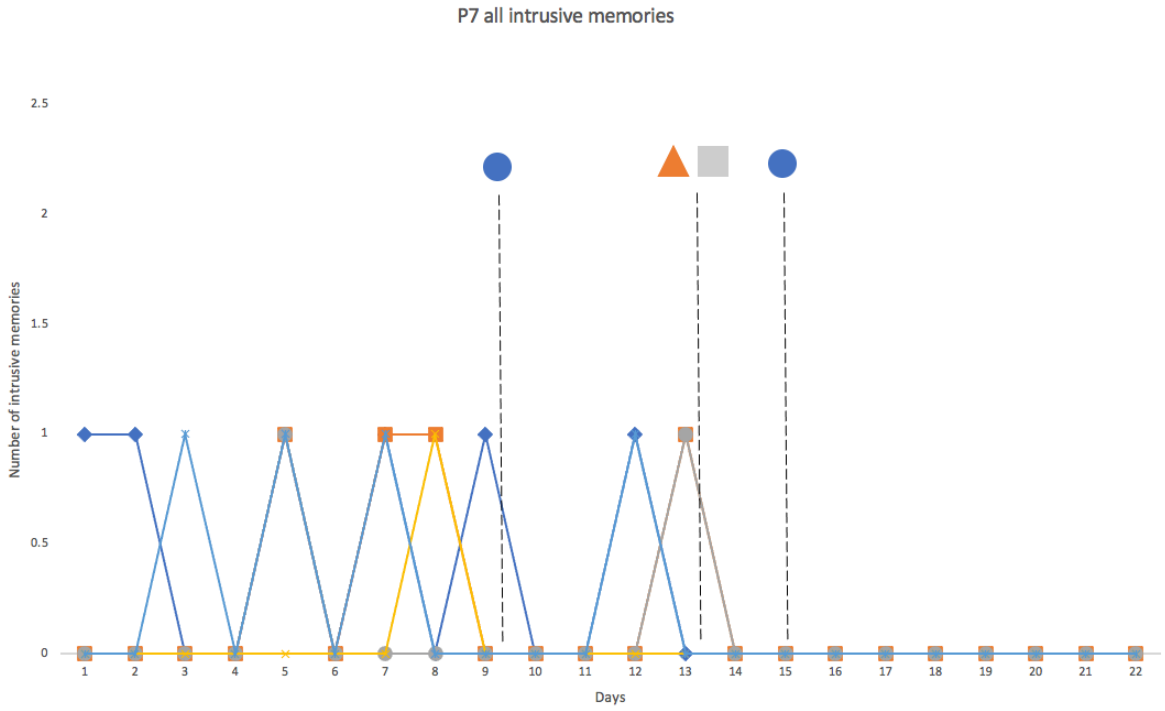


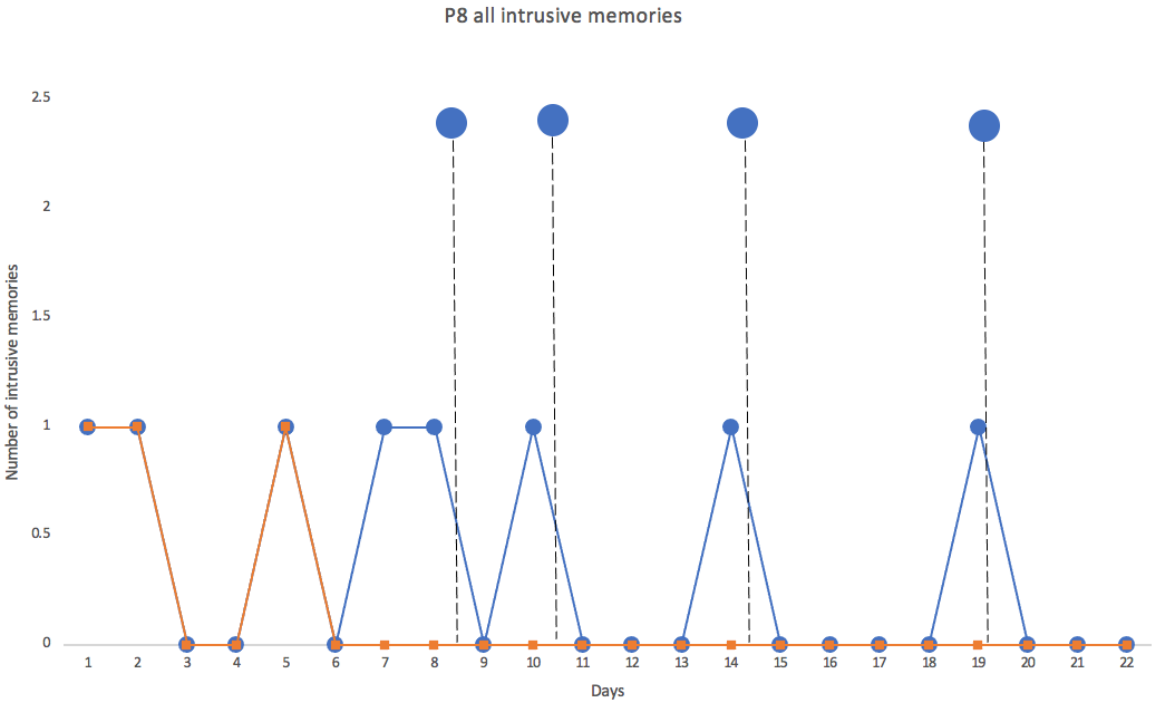

P3 all intrusive memories
Number of intrusive memories
0
1
2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days

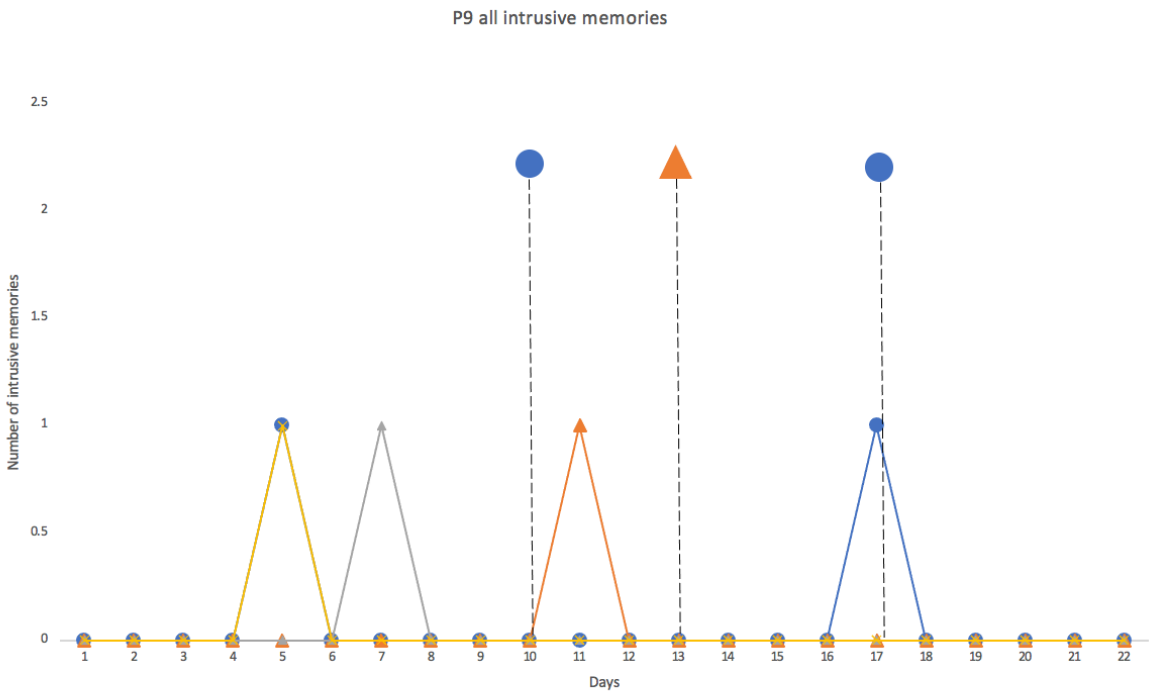

P4 all intrusive memories
Number of intrusive memories
0
1
2
3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days

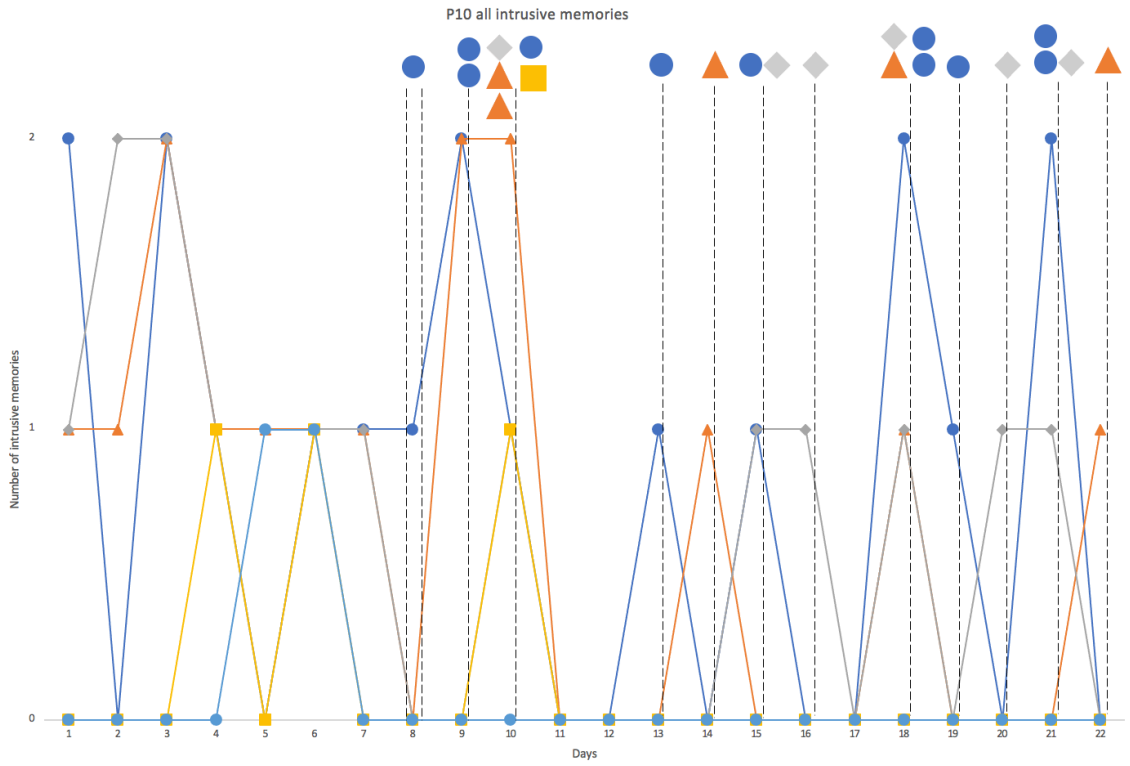

P5 all intrusive memories
Number of intrusive memories
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days

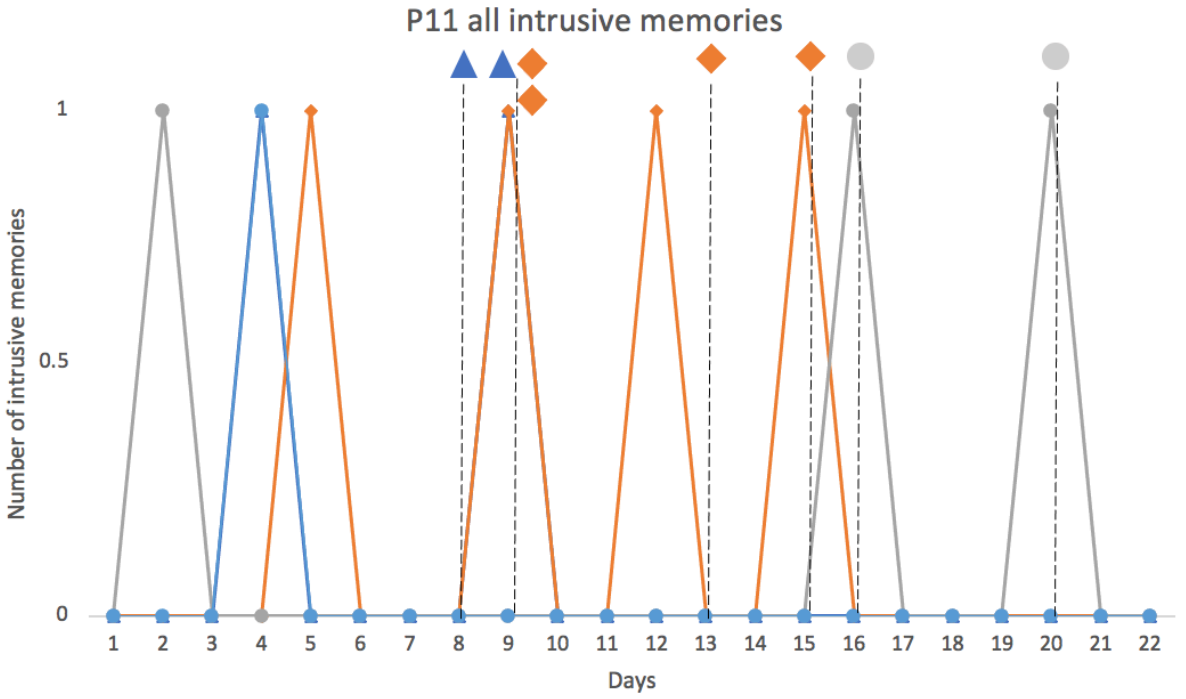

P6 all intrusive memories
Number of intrusive memories
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days


P7 all intrusive memories
Number of intrusive memories
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days


P8 all intrusive memories
Number of intrusive memories
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days


P9 all intrusive memories
Number of intrusive memories
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days


P10 all intrusive memories
Number of intrusive memories
2
1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days


P11 all intrusive memories
Number of intrusive memories
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days

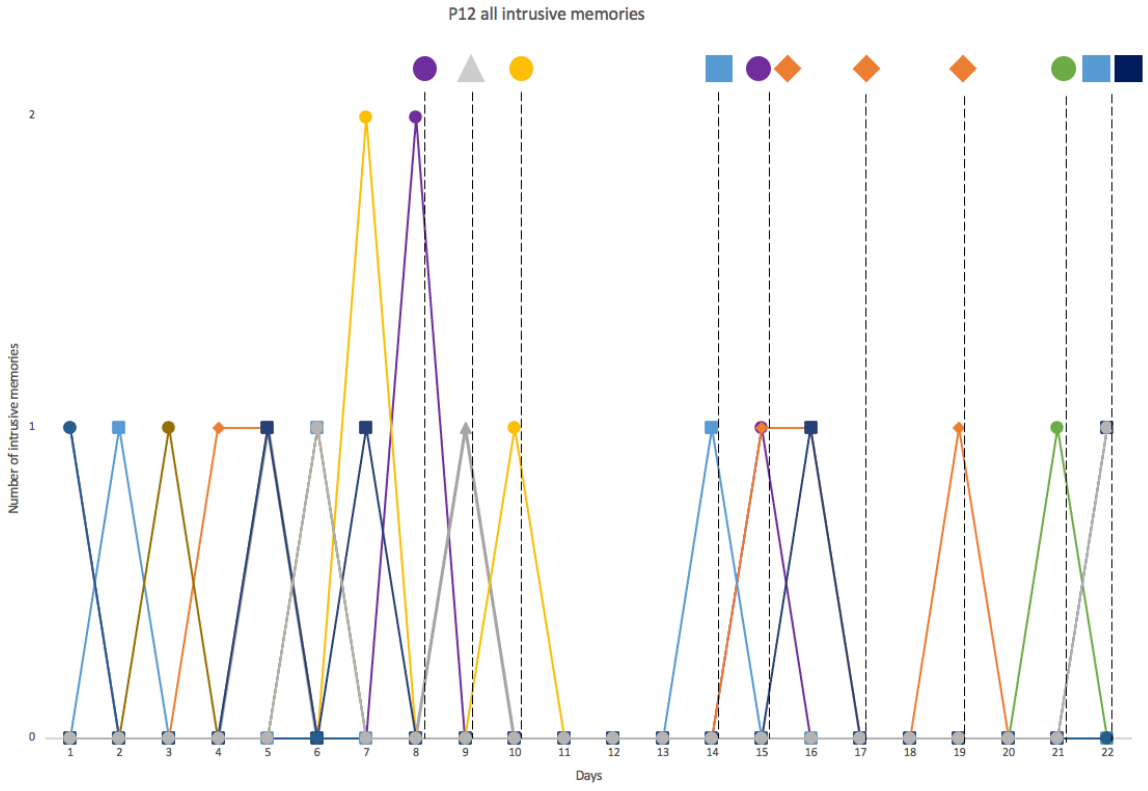
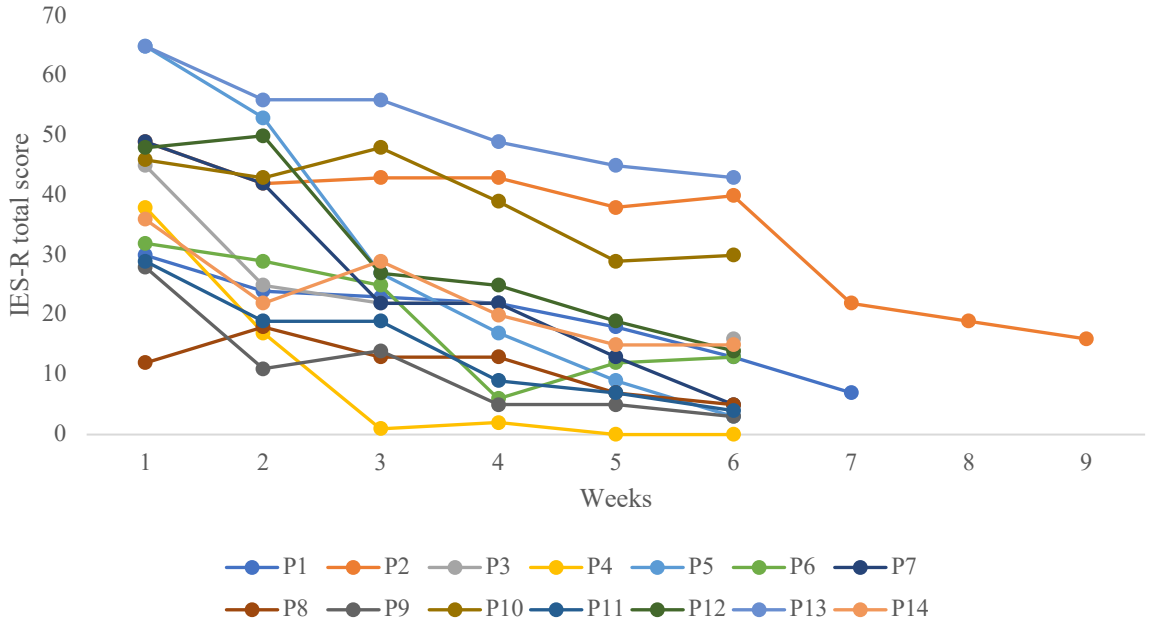

P12 all intrusive memories
Number of intrusive memories
2
1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days

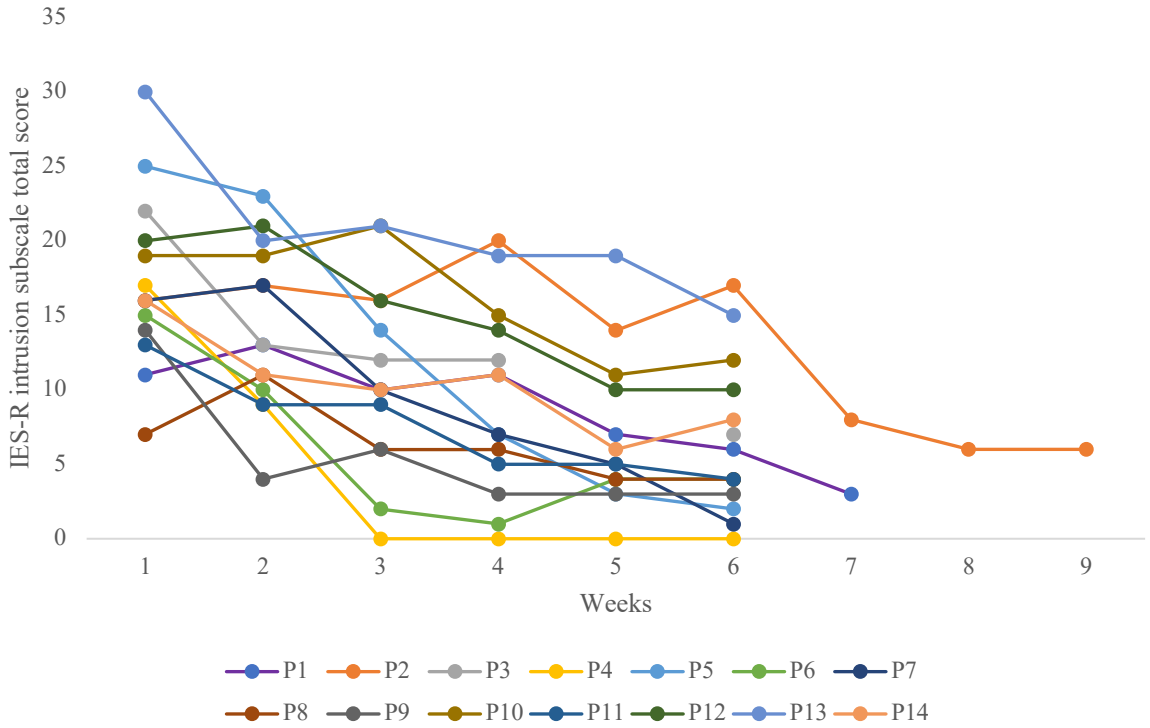


Figure A29. Individual participant time courses for all intrusive memories per participant, excluding new intrusive memories. The number of intrusions per day (y-axis) is plotted by each day of the study period (x-axis). Time points when the interventions were delivered are depicted by a vertical dashed line with an accompanying label corresponding to the intrusion that was targeted by a specific intervention. If there were several interventions delivered in one day, this is represented as multiple symbols above the dashed line. Where the dashed line is shown after the intrusion, this represents an intervention being delivered after an intrusive memory occurred. The dashed lines represent both researcher-assisted intervention and boosters, as well as participant-administered boosters. The time period before the first dashed line, i.e., the first intervention being delivered, is the baseline, 'A', period, for each participant. For the majority of participant's individual intrusive memories a downward trend

in intrusive memory frequency can be observed from baseline to post-intervention. Gaps seen in the data points represent missing data.

Appendix 30: Graphs of individual mental health symptoms





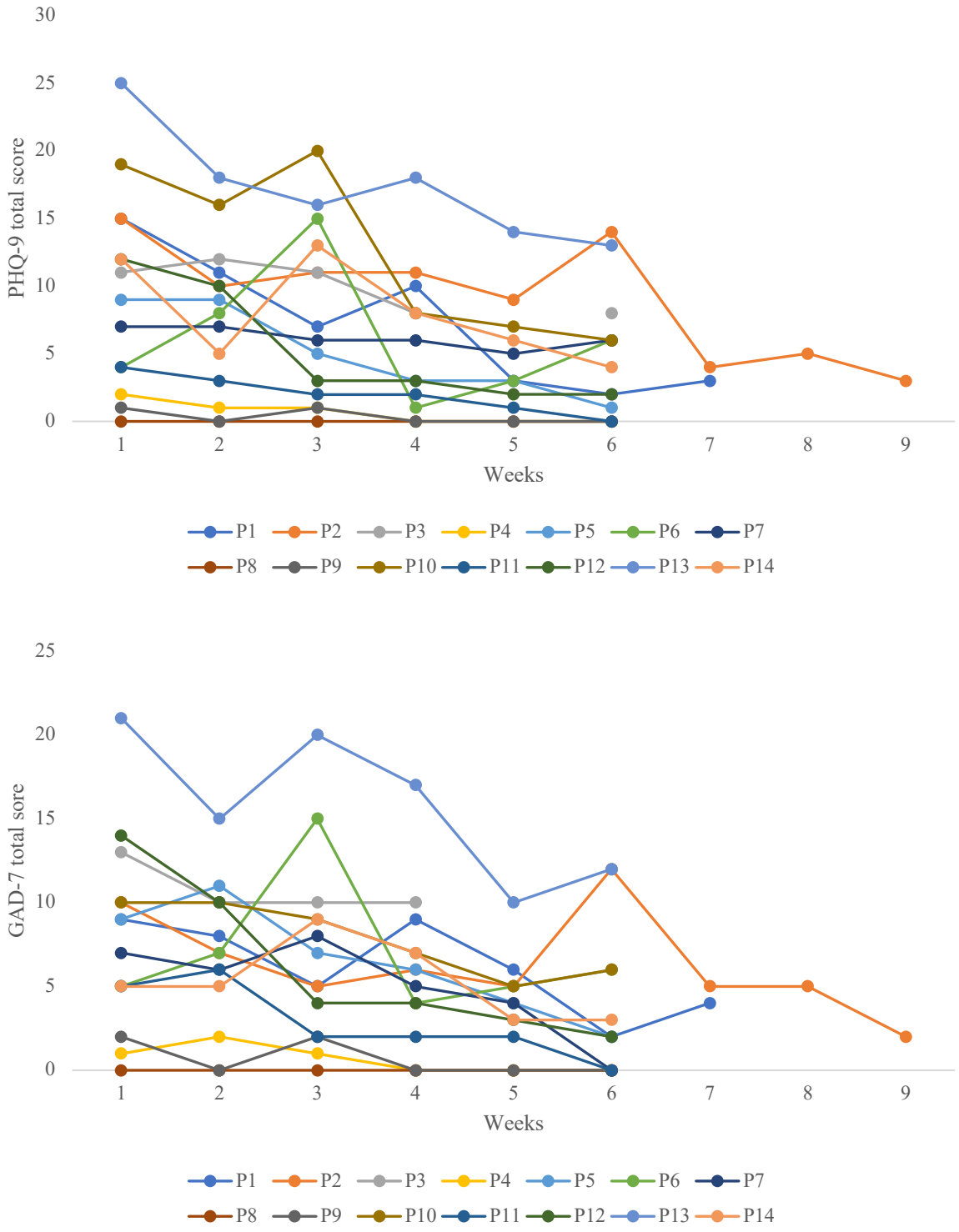


Figure A30. All participant's secondary outcome measures including IES-R total, IES-R intrusion subscale, PHQ-9 and GAD-7 scores represented graphically. The outcome measure score (y-axis) is plotted at the beginning of each week. Week one represents the baseline outcome measures recorded at the Screening and Eligibility assessments (first session) for each participant. For participants three to fourteen, outcome measures recorded at week six represent a one-month follow-up.

Appendix 31: Participant feedback table

Table A31. Participant feedback to open-ended questions (n = 14).

Themes	Participant quotes
Positive comments about Tetris and the study	"I've been telling people I've been playing Tetris and that it's been very good. I like that it is so easily accessible and anonymous."
	"People need to be open minded to [the study] and try it properly. It's just been amazing."
	"If it was presented as an integrated part of some sort of counselling, then it might be accepted a bit better. "We've all had a cardiac arrest on the ward, let's all play Tetris for 10 minutes". We perceive that we want to include our colleagues in our experience - we are part of a team and we are here for each other. You want to tap into that. When you bring up an intrusive memory, the other person will also recount their experience - this becomes a natural therapeutic experience."
	"When I played, I noticed instantly that it helped - it's very quick to concentrate on and to play. The first 5 or 10 minutes is enough for all the memories to go away."
	"It does take your mind off what you're thinking - gives you a chance to calm down. A 'distraction therapy'."
	"It's quite fun really!"
	"There's nothing to add because it helped. It did what it was supposed to do - when I was feeling down, it made me feel less sad about the incident. It replaced a bad feeling with a good feeling."
	"It's all well planned out - nothing much else that can be improved."
	"You approached us very sensitively. Very well informed about the risks, even though they were minimal. It wasn't too taxing."
	"I think it was really well done - the links came through very quickly and the reminder text messages were helpful."

	“It's quite self-explanatory, it's easy to use. Nothing else that can be done to make it any easier.”
	“The study has been so fluid and easily accessible. Once people are in, they would stick with it because it’s so easy and so good. It’s just about getting people into the study.”
	“It was really good and different, it's nice that it's about [my] experience and talking about what could help. I found that very interesting.”
	“I'm really grateful that it was advertised at work and I was able to take part so easily. The intrusive memories that were bothersome no longer feel bothersome. I think it was very effective for me. I could have paid for therapy or gone down occupational health route, but I didn't feel like I needed to. The poster was so specific - the examples on the poster were very specific, so I could say "yep, this is exactly me". Whereas occupational health posters are very general and talk about addressing mental health. To have a very specific example of the issue really made me think "Great, I can really sort this out".”
	“I personally found it quite helpful. I believe it's helped me and improved things for me. All the reminders and links to the pages were good - it didn't take much of my own time. I need a lot of nudging - so the nudging was very helpful!”
	“It was very easy, and you were very helpful and it was easy to get in touch with you when I needed it.”
	“It was good and it was right time for me that it had come round. The fact that I had the incident so recently... it helped me deal with my emotions and talk about it.”
	“It's been very good and very easy to join and well explained.”
	“I found the study very interesting, it made me realise how the event has affected me and that I need to take care of myself. The intervention decreased the intrusive memories a bit – [I] did something active about it.”
	“All was good and was helpful to get things explained. Having the 1:1 sessions were nice, putting a face to the study.”

	"The study seems to have helped me. There's still a few memories popping up but the impact on daily life is markedly less."
	"It takes your concentration somewhere else."
	"It was helpful to dissociate from work in the game – cutting off from what's around you."
	"I've kept it in my phone, and I play it from time to time following intrusive memories of other events in my life. It's a massive distraction."
	"Extremely helpful - it gave me down time and focused on something completely different."
	"I just found it really brilliant. A bit worried I might get addicted to it! It's probably not ground-breaking for many people who already play computer games, but for me having never played any, I found it really great. If you need a Tetris ambassador, I'm your person!"
	"When I had the intrusive memory this week, it didn't have such a strong emotional potency and didn't have such a hold of me. You can deal with the memory better when it doesn't have such a strong emotion attached to it. I can really see the benefits."
Comments about playing Tetris at work	"It's not practical to do Tetris at work – it's really hard to do it when on the road, especially to do the 25 minutes. There's no time for it at all. For example, I either have to go to a job or when I have [the intrusive memory] with a patient, I'm not able to do then either. With mine [intrusive memories] it was the triggers which was when I was at the back of the ambulance and certain jobs – therefore in these circumstances it would not have been possible to play at all. The whole idea is a great one but practically it's very tough. People might be more willing to re-activate their memory on their own – but it would depend on the person of course."
	[With regards to how easy it is to play Tetris at work] I'd either give it a 10 or 0. I was either in the position to play [Tetris] or I wasn't. I was either on a work call or I wasn't. [Throughout the study] I was more often able to play [Tetris]

at work than not. I was always able to do the full 25 minutes. I don't think I was ever disturbed playing it at work, but I could have been pulled away at any moment."

"The only time you could do it [play Tetris] [at work] is in the breaktime. We get an hour."

"Playing at work has been hard – finding 25 minutes has been tough. At home it's been alright."

"Playing [Tetris] is okay, it's just about the time. We don't have that much time at work. I managed to play once on a night shift when it was quieter. If it was a day shift, I don't think I would have managed."

"Not possible [to play Tetris at work] as there's no internet – so it couldn't be accessed on my phone. If I had let my managers know that I was taking part in the study then they would have probably let me have some time to do it. Practically it would be really tricky – it would be hard to have time out of work to do the intervention for half an hour, if it weren't a scheduled break. Getting cover at the right time. Nion impossible to do it at work."

"When it's quiet it's easier to play, but not when it's busy at work."

"To people who haven't had it explained, might seem a bit trivial - people might question it if you are playing Tetris at work, as it's a game."

"The environment is tough to allow playing Tetris in the emergency department. On one of my shifts […] I had an intrusive memory. I took the patient upstairs [to a ward] and while waiting for the procedure to finish I was able to play Tetris on my phone. This was great, but it wouldn't really be possible in the emergency department. It's very ward dependant in terms if you can get some time or space to play."

"Playing in the emergency department probably wasn't as helpful as it could have been. It did make a difference but not as much as if I was at home and playing it. It's much easier to focus on it at home. During breaktimes is the only time that's possible [to play Tetris], however even then, the staffroom is very busy and it's hard to concentrate. You might have others

	asking you to join in a conversation and you don’t want to be seen as anti-social.”
Suggestions for improvement	
Having Tetris on an app	“Having it on an app to shorten the time between thinking "I should do this" and playing.”
	“It would have been easier to have an app. The website can be a bit slow. The app might be a bit more accessible.”
	“Going onto the website was a bit of a hassle.”
A version without advertisements	“The game is as it is - classic and perfect. If there was a version without adverts.”
Shorter play time	“I would advise a bit less time, for it to be shorter, but other than that it's fine.”
	“The length of time was bothersome, rather than the actual playing – it felt like it went on for a long time.”
	“The only thing I would say would be to play Tetris for little less time so that we could do it at work.”
	“…this would have reduced the risk of being called away to a job.”
Highlighting the importance of focusing on the mental rotation of the three pieces coming up next and planning ahead	“The real focus is recognising that you have to focus on the shapes coming up next. You could effectively just get bored. You need to focus and that's what helps you switch off from the external world.”
	“It works when you're thinking ahead about the pieces falling next.”
Tetris game play only up to certain level	“When I was at the lower levels, I felt calm, but when I was in the higher levels and the pieces were dropping very quickly and I couldn't focus on the three pieces coming up next - I was too distracted by the piece being played immediately. If it was fixed at a level 6 or 7 that would be ideal - it wouldn't be too fast, and you could focus on the actual task of rotating the pieces in your mind.”
Reminders to play Tetris	“It's difficult to use while working long days but perhaps a reminder to play Tetris on a day off might be useful.”

	"When on nights having a later reminder to complete the intrusive diary."
	"Whether you use text or email. Text was best for reminders and not phone as my phone is almost always on silent. Giving people the choice around how they want to be contacted for different reasons"
Intrusive memory diary recommendations	"If you're dealing with people on shifts, making sure you explain to them that it's okay to do the diary on the day after. Sometimes it's not possible to do it on the same day. Apart from that it was all very self-explanatory and easy to access."
	"Simple things: log on to the website - having to put in my participant number and date took a bit of time. Having something which says, "welcome back participant number x!" might make it seem a bit more friendly."
Other comments	"I wouldn't be super confident in telling people about the benefits - the science behind it."
	"I didn't feel comfortable telling my nurse in charge that I need to go play Tetris."
	"The majority of my memories are from years ago. I wonder if using it after the jobs I did recently, whether targeting the memories in the acute [stage] would be helpful. I wonder how this would be different with long-term memories versus acute memories. The initial hours and days after the event, I want to think about it - I reflect on the events quite deeply. I think this isn't the case for other people. I tend to think about it a lot."
	"I think that you may need support from senior staff to allow staff to take time out from the clinical area to do this."
	"I found it difficult to understand why I was doing it – I could see it as a distraction, but if I had to wait between having the intrusive memory and playing later, that didn't quite make sense why I was doing it that way or how it would help."
	"I'm very chatty and open to talking about my experiences, but there are people who need to be on this study but aren't. Some people wouldn't

	want to open up and talk about their bad experiences. Maybe having a link to a private diary, where they can record their traumatic events/intrusive memories, and then you have a look at it later. More of an indirect approach. When I've talked to people about the study, they said, "talking isn't really my thing". I also think that having an incentive to participate would be helpful. Make it clearer from the beginning that reimbursement is offered." "In the questionnaires - did not have a 'not applicable' option - this might have been more comfortable to select as an option." "The emergency department is overlooked. Because I'm a senior nurse, people think I don't need the help – they think I'm used to trauma. I wasn't invited to a [post-event] debrief whereas everyone else involved in the event was." "Taking part in the study is not burdensome, more awkward. The difficulty was sometimes fitting in the telephone calls or additional interventions – I'm not very organised so on a personal level it's been a little tricky. You were very flexible which was very helpful." "When colleagues describe intrusive memories, the expectation is that we sit there and listen. Culturally we are not there yet, to do something that might distract away from the memory. It might come across insensitive or that I'm not interested." "Depending on who the paramedic is – some I'm very friendly with and others – if I had suggested it to someone I wasn't as friendly with "have you thought of playing Tetris when you're struggling, I imagine they would say "what the hell?!" it really depends on the type of person you're talking to."

Appendix 32: Intervention booster information

Intervention boosters

94 intrusive memories were reported during the entire study period by participants three through to fourteen following the delivery of the first researcher-assisted intervention in the post-intervention period. Of these, 76 were targeted with either a researcher-assisted intervention booster or a participant-administered booster, meaning that 81% of possible intrusive memories were targeted with an intervention booster.

Table A32. Booster sessions. Total number of possible boosters (both researcher-assisted and self-administered) and the actual number and percentages that were administered following intrusive memories experienced by participants three through to fourteen.

Participant number	Number of intrusive memories for which it was possible to administer booster sessions	Total number of booster sessions administered	% of boosters administered following intrusive memories
P3	16	4	25
P4	1	1	100
P5	6	4	67
P6	0	0	N/A
P7	4	3	75
P8	3	3	100
P9	2	2	100
P10	25	23	92
P11	7	7	100
P12	12	12	100
P13	13	13	100
P14	5	4	80

Appendix 33: Impact of COVID-19 on participants

Table A33. The table below illustrates the impact of the COVID-19 pandemic as reported by the participants in the study. Where there has been a known direct threat to life or serious injury due to the participant having contracted COVID-19, this is classified as a 'direct' impact. For those participants who have reported being affected by the pandemic in any other way, this is classified as 'indirect'. Where the impact of the pandemic was not spontaneously reported by participants and the content of their intrusive memories were not COVID-19 related, the COVID-19 impact rating is given as 'unknown'.

COVID-19 impact	Number of participants	Note
Direct	1	Threat to own life as a result of contracting COVID-19 infection.
Indirect	6	Reported extreme work-related pressure due to limited resources and overwhelmed department as a result of the COVID-19 pandemic. Reported being relocated to another ward and carrying out professional duties which they ordinarily would not be, which resulted in added stress. Due to the COVID-19 pandemic, volunteered as a medical student on the frontline. Due to COVID-19 risk, was wearing Personal Protective Equipment (PPE) when asked to assist in a medical emergency. Discomfort and feelings of disgust from wearing the PPE linked to the currently experienced intrusive memories of the work-related traumatic event. Heightened levels of stress resulting from expecting a COVID-19 wave on the ward. Worries about staffing levels and vulnerable babies. Intrusive memory linked to COVID-19 pandemic related fear and uncertainty. Heightened levels of stress resulting from expecting a second COVID-19 wave on the ward. Anticipatory anxiety related to thoughts about the second wave being worse than the first. Needing to self-isolate for 14 days had disrupted the usual work pattern. This may have influenced the number of intrusive memories the participant was experiencing as well as any functional outcomes. During the second wave of COVID-19 reported feeling extreme work-related pressure due to an increase in clinical work: "things have been horrendous at work recently due to COVID-19 – I'm now used to it, but it has been hard and very busy."
Unknown	7	Not applicable