**TITLE:** The development and protocol for testing a co-created digital intervention (Sentinel) to improve mental wellbeing and help manage and prevent trauma in first responders.

## ABSTRACT

First responders (FRs) are at high risk of being exposed to traumatic events in their occupational roles. Limited evidence-based support has been offered to FRs who have experienced occupational trauma using digital interventions (DIs). **OBJECTIVE:** To gain evidence from FRs relating to the impact of exposure to occupational trauma and describe the development of and planned protocol for testing an evidence-based, co-created DI called Sentinel to help manage and prevent trauma among FRs. **METHODS:** In phase 1, we conducted 52 interviews with FRs from fire and emergency, police, and emergency healthcare to explore the needs, views and experiences on using DI to support mental health. During phase 2, we developed the DI (Sentinel) content in consultation with current evidence, policy, theory and FRs experience. In phase 3, we plan to conduct a series of codesign workshops and development sprints to test and refine the DI (Sentinel). In phase 4, we will conduct a mixed methods non-randomized study to determine the feasibility, acceptability, usability and safety of the DI (Sentinel). **RESULTS:** We expect data to be collected from up to 50 FRs for feasibility testing. We expect to conduct approximately 30 qualitative interviews with FRs who engaged in the Sentinel trial and 20 health and social care professionals who referred FRs to the study. **CONCLUSIONS:** This study will provide preliminary evidence on the feasibility, acceptability, safety, usability and implementation potential of the DI (Sentinel). The findings will inform the decision to proceed with a powered efficacy trial.

The development and protocol for testing a co-created digital intervention (Sentinel) to improve mental wellbeing and help manage and prevent trauma in first responders

**CLINICAL IMPACT STATEMENT:** FRs are at increased risk of traumatic stress-related conditions resulting from exposure to work-based traumas. DIs can improve help-seeking behavior among FRs and could identify early signs of distress and provide timely support at a point when help is most needed and people are ready to engage, thus preventing conditions from worsening. Sentinel is a DI that has been developed using a participatory co-creation approach and, if successful, could be implemented on a large scale to meet the increasing demand for mental health support and reduce the burden on health care services.

## INTRODUCTION

First responders (FRs; police, fire and ambulance officers, military, veterans, emergency healthcare workers) are at increased risk of experiencing traumatic stress-related conditions resulting from exposure to work-based traumas (Cogan et al, 2022; Geuzinge et al, 2020; Klimley, et al, 2018; Knobloch, & Owens, 2023; Krantz, et al, 2022). FRs are exposed to unpredictable and/or dangerous environments, demanding workloads, and heavy emotional labor making such occupations unique in terms of their demands (Johnson et al., 2018; Stansfeld et al., 2011).  Almost 90% of FRs describe repeated workplace exposures to incidents that involve direct threats to their lives and/or witnessing the deaths and horrific injuries of others (Berger et al., 2012; Boffa et al., 2016). Work-based traumas have been found to result in a prolonged negative impact on the mental well-being of FRs including a heightened susceptibility to post traumatic stress disorder (PTSD), anxiety, depression, chronic fatigue, burnout, and suicide (Back et al, 2023; Beauchamp, & Jetelina, 2022; Kim et al, 2019; Vizheh et al., 2020). These conditions are associated with higher rates of absenteeism, poorer work productivity and unhealthy lifestyle behaviors (including low levels of physical activity and high levels of sedentary behavior) with a resultant impact of poorer physical and mental health and increased risk for chronic disease (Alshehri et al, 2023; Meckes et al, 2021; Somville et al, 2023; Tan et al, 2023; Williams & Williams, 2020).

Despite the significant risk of developing mental health problems among FRs due to the nature, frequency, and intensity of work-related traumatic exposure, the work-placed culture of FR organizations strongly esteems strength and self-reliance, which often inhibits FRs from seeking mental health care and

support (Jones et al, 2020). Barriers to mental health help seeking exist with FR organizations where the need for support or seeking help for mental health is often viewed as a form of weakness and/or as a barrier to professional advancement (Drew & Martin, 2021; Motta, 2023). Over one third of FRs experiencing mental ill-health do not seek support due to stigmatization, shame, and confidentiality concerns (Auth et al., 2022). Although intervention research in this area is limited, the latter concerns appeared as key barriers to help seeking behaviors throughout various systematic reviews assessing the acceptability of available interventions across FR occupations (Alden et al., 2020; Clark et al., 2021; Winders et al., 2020). Systematic reviews have attempted to synthesize the effectiveness of available interventions with FR populations. For example, Smith and Roberts (2003) identified 10 intervention studies with FRs and tested their effectiveness, concluding that all interventions lacked quality given general limitations such as poor reporting, inadequate sample sizes, low response rates and sampling bias. Further, a need for more detailed description of treatment activities or reference to established treatment protocols has been recommended (Haugen et al. 2012). Alden et al. (2020) found that within 21 intervention studies for FRs, uptake and acceptability of interventions was low and there was a lack of studies incorporating qualitative data drawn from interviews with FRs to help provide information as to what aspects of the intervention they perceived as more or less helpful. Studies included individual or group psychological interventions delivered by clinicians (e.g., psychologists) and non-clinicians (e.g., experienced supervisors). It was recommended that researchers incorporate FRs' views of their workplace (e.g., stressors, support) and to draw participants from multiple organizations to collect both qualitative and quantitative information directly from the FRs (Nielsen et al., 2010).

The need for studies that incorporate participatory methods that involved FRs' in the early stages of intervention development has also been emphasized (Alden et al, 2021); this approach provides information about FRs' views as to what they would find most helpful in supporting their mental health needs and the circumstances under which mental health interventions work or do not work. Recent work has highlighted how FRs experience challenges in accessing and engaging in face-to-face mental health care and support (Johnson et al, 2020) as well as FRs' anticipating negative outcomes from treatment, stigma, and how structural barriers inhibit treatment engagement (Zolnikov & Furio, 2020). Intervention research incorporating participatory methods from the onset has been found to improve engagement and uptake

(MacIntrye et al, 2018; Wallerstein & Duran, 2010). These treatment engagement factors likely interact at various time points and influence FRs' mental health outcomes. Additionally, Winders et al. (2020) investigated intervention research across FRs and concluded that interventions focusing on the prevention of mental health conditions (opposed to the treatment of) were most effective in lowering the susceptibility of developing conditions (Bisson & Olff, 2021). Although intervention research was limited, much of the systematic reviews agreed that more qualitative research using participatory methods was needed to gauge the specific lived experiences and mental health needs of FRs (Alden et al., 2020; Alshahrani et al., 2022; Winders et al., 2020) and that future intervention should aim to address the stigma surrounding mental health help-seeking and prioritise a preventative approach to mental ill-health (Clark et al., 2021).

In more recent years, digital interventions (DI) have become increasingly popular to overcome existing barriers in accessing mental health support (Borghouts et al., 2021). Studies have shown that DI have been effective in addressing barriers related to stigma and accessibility present within face-to-face interventions (Gulliver et al., 2010). Although DI in the form of mobile applications (apps) or websites have also been shown to present their own problems in that they are dependent on the ability to use and access digital technology (Dixon et al., 2016), they have shown to be highly effective in the treatment of mental health conditions (Borghouts et al., 2021).

Internet and mobile technologies offer potentially critical ways of delivering mental health support (Ruzek, & Yeager, 2017). While there has been very limited research involving DI with FRs to date, recent studies have reported that DI have the potential to improve mental health help-seeking behavior among FRs (Blake et al, 2020; Newell, et al, 2022; Yoon et al, 2021). They offer the opportunity to identify early signs of distress and provide timely support, preventing mental health problems from worsening. They can also provide support on a daily basis, at home or work and at a point when help is most needed and FRs are ready to engage. In addition, they can be implemented on a large scale to meet the increasing demand for mental health support and reduce burden on mental health services (Taylor et al, 2020). Nonetheless, research with FRs that are exposed to high rates of occupational trauma is limited, and it is not yet clear as to how DI can be developed to meet the mental health needs of FRs and ensure that they do not create or exacerbate traumatic experiences (Wickersham, et al, 2019). The need for researchers and DI developers to deeply understand users' needs and/or experiences is increasingly recognized (Harrison et al, 2011). This requires

researchers to directly ask participants about their experiences in a trauma-informed way through interviews, focus groups, surveys or workshops (Chen et al, 2023). These forms of participant engagement have the potential to cause retraumatization by requiring people to remember and recount traumatic events (Isobel, 2021). In line with the goal of avoiding retraumatization, researchers should carefully consider how their research may be retraumatizing and work to minimize potential harm. A trauma-informed approach to DI user research (Wong, 2021) involving qualitative methods requires researchers to be attuned to the power dynamics in researcher-participant relationships, be transparent about the research's goals, expectations and procedure, have skills in managing participant distress, and give the participants autonomy, flexibility and opportunity to withdraw their participation if needed (Chen et al, 2022). Equally, it is important that researchers conducting qualitative research on trauma need to recognize the potential for vicarious trauma and implement appropriate protection and self-care strategies (Casas & Benuto, 2022), as well as to plan for researcher safety and well-being from the onset of the research (Smith et al, 2023).

We describe a participatory, co-creation approach to developing a DI that aims to help manage and prevent traumatic stress among FRs, Sentinel, and in our plans to pilot test this DI. The importance of understanding and accommodating the perspectives of the FRs at all stages of its development and testing is central to our research and design process. While DI designers seek to elicit and incorporate the views of users in a range of ways, a person-centered, co-creation approach offers a systematic means of understanding the user experience and can enhance the use of evidence-based approaches to DI development (Lember, 2018). The first step involves qualitative research with a wide range of people from the target user populations, carried out at every stage of intervention development, from planning to feasibility testing and implementation (Yardeley, et al, 2015). This process enables intervention designers to build a deep understanding of users' needs in terms of the psychosocial factors as well as behavioral elements of the digital intervention (Mitchie et al, 2017). Insights from this co-creation process can be used to anticipate and interpret intervention usage and outcomes, and, importantly, to modify the intervention to make it more acceptable, feasible, credible, and relevant to users (Yardley et al, 2016). Adopting participatory methods that involve FRs in all stages of intervention development can help highlight the distinctive ways that the intervention will address key context-specific social and behavioral issues facing FRs in meeting their mental health needs (Borghouts, et al, 2021).

**OBJECTIVES**

This study will be the first to develop and test a DI (Sentinel) for the management and prevention of trauma among FRs using a participatory, co-creation approach. This work is reported here in four phases, with objectives for each phase as follows. **Phase 1:** to explore the need, views and experiences of using DI to support mental health. **Phase 2:** to develop the DI (Sentinel) content in consultation with current evidence, policy, theory and FRs experience (explored during phase one). **Phase 3:** to conduct a series of codesign workshops and development sprints to test and refine the DI (Sentinel). **Phase 4:** to conduct a mixed methods non-randomized study to determine the feasibility, acceptability, usability and safety of the DI (Sentinel).

**METHOD**

**Intervention: Sentinel**

In the phases outlined below, we describe the development and protocol for testing a novel digital application, Sentinel, to support trauma management and prevention in FRs. The innovation lies in the way the Sentinel platform learns and adapts its prompts depending on user interactions. The app will continually evolve and personalize interventions supporting trauma management and overall health. The app will be available in a series of sector-specific variants that include Sentinel Care (NHS), Sentinel Blue (Police), and Sentinel Red (Fire Service), all of which deliver a unique experience specifically designed and tailored for individuals in that sector. Sentinel has been developed through the collaboration of expertise from behavioral science, physical activity and health, mental health, digital health and intervention development. This multidisciplinary combined approach is novel in helping to develop an evidence-based and co-created product that is well beyond what is currently available in the market.

The development of Sentinel and the protocol for pilot testing this digital intervention consists of 4 phases:

**Phase 1:  User engagement and planning**

We conducted an initial market analysis with key stakeholders, which highlighted the need for an app such as Sentinel in the current digital applications market. Furthermore, we have seen a huge demand for CPD workshops (led by NC) on trauma awareness and management from FRs and frontline workers and this further supports the market gap. We sought and gained ethical approval to conduct an in-depth qualitative investigation into FRs' exposure to work-placed trauma and their views and experiences on using DIs to support their mental health needs. Having gained informed consent, we conducted in-depth, online individual interviews with FRs (total, n = 52) from a range of organizational contexts (Fire and emergency n = 17; police n = 5; paramedics n = 18, emergency healthcare workers n = 14) using the Teams platform. All interviews were provided with in-depth training on conducting qualitative research in trauma, interview techniques, managing distress, maintaining safety, awareness of vicarious trauma in researchers and self-care (AbiNader, et al, 2023). The research team also held regular reflexive meetings to discuss the research process and provide support throughout the conduct of the research. All interviews were transcribed in full verbatim and analyzed using a reflexive thematic approach (Braun & Clarke, 2021). While a full account of the themes developed is underway, the major themes as follows: (1) The pervasive and salient impact of occupational trauma on mental health (self and others); (2) The demands of the job exacerbating the adverse effects of trauma; (3) Insufficient support or access to psychological input following exposure to trauma; (4) Stigma and fear of judgement as barriers to mental health help-seeking; (5) Need for accessible, credible and timely trauma focused interventions and workplace support; and (6) Perceived acceptability of digital-based interventions (need for safety, anonymity and confidentiality). The implications of these findings emphasize the importance of implementing a strengths-based, non-pathologizing and de-stigmatizing approach to trauma in the workplace as experienced by FRs. The importance of overcoming barriers to accessing mental health support and improving access to evidence-based trauma-focused psychological interventions and workplace support was evident across FRs' accounts. The perceived acceptability of using a DI to support their mental health needs was reported, however, participants emphasized the need for safety, privacy and anonymity when using the DI as well as opportunities to connect with other FRs either face-to-face or on a digital platform as important considerations. These findings provided evidence as to the impact of exposure to work placed trauma on FRs and the importance of overcoming barriers to accessing mental health support.
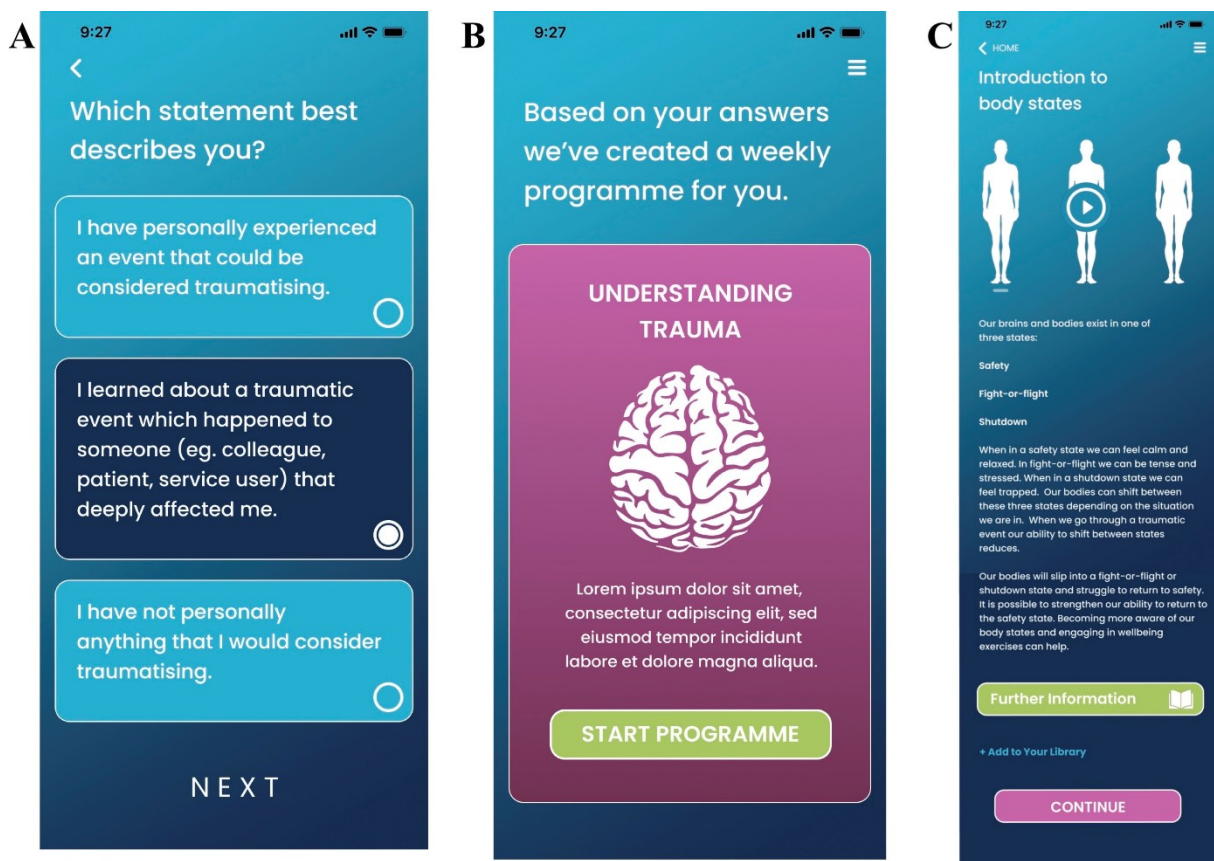
The development and protocol for testing a co-created digital intervention (Sentinel) to improve mental wellbeing and help manage and prevent trauma in first responders

The acceptability of digital based interventions as a means of providing flexible, accessible and credible help was supported. These themes informed the next phase of intervention development.

**Phase 2: Evidence-based and user-informed content creation**

The second phase of developing Sentinel (creation of content) has been completed. The first step of designing the Sentinel app consisted of developing a list of six evidence-based "personas". These are app user (FRs) profiles relating to information that users input relating to their presenting problems at the onset of using Sentinel (see Figure 1). The "personas" allow Sentinel to decide what intervention modules to give to users, and when, depending on their experience of traumatic stress and other core presenting problems (comorbid anxiety and/or depressive symptoms).

**Figure 1.** Wireframes



Wireframes showing (A) Sentinel asking the user to answer a question to begin determining their "persona"; (B) commencement of a tailored program for the user; and (C) one piece of content within the app.

The development and protardd for testing a co-created digital intervention (Sentinel) to improve mental wellbeing and help manage and prevent trauma in first responders

The second step involved creating the in-app evidence-based module content. With consultation of current evidence (Bryant, 2022; Bisson & Olff, 2021; Brown & Courtois, 2019; Forneris et al., 2013; Hamblen et al., 2019; Lewis et al., 2020; Qi et al., 2016), policy (NES, 2017), theory (Dana, 2018; Griffith et al., 2022; Whealin et al., 2008; Porges, 2022), and experts by experience in stage 1 (FRs), a total of 290 pieces of content were generated, spread across 58 modules (see Figure 1C for an example piece of content). The modules are classified into 10 different categories (see Table 1).

**Table 1**

*Categories of Sentinel's Modules*

| Category | Description | Number of Modules | Number of Pieces of Content |
|---|---|---|---|
| Increasing knowledge of trauma and traumatic stress | Provides psychoeducation on primary and secondary trauma and stress. | 3 | 7 |
| Increasing knowledge of post-traumatic growth | Provides psychoeducation on post-traumatic growth, and an exercise to foster optimism. | 2 | 4 |
| Increasing mind-body and emotional state awareness | Provides exercises to bolster awareness of body state and emotions. | 12 | 61 |
| Learning strategies to cope with present distress | Provides self-help and problem-solving strategies to cope with stressors. | 15 | 82 |
| Improving general mood and affect | Provides short exercises to improve mood and affect. | 10 | 38 |
| Improving sleep | Provides psychoeducation on sleep and strategies to improve sleep. | 5 | 16 |
| Improving social connectedness | Provides a strategy to increase and strengthen user's social connections. | 1 | 3 |
| Increasing levels of physical activity | Provides aerobic, strength, endurance, and resistance exercises to promote physical activity. | 4 | 67 |
| Reducing levels of sedentary behavior | Provides psychoeducation on sedentary behavior, tips to reduce it, and short exercises. | 5 | 9 |
| Increasing resilience | Provides an exercise to increase resilience to future traumatic events. | 1 | 3 |

Rules were set in place to ensure content was clear and easily digestible. Specifically, each piece of content aimed to be no longer than 500 characters and to have good readability. Readability was tested using

the Hemingway Editor, where "good" readability was considered a score of 9 or below. In addition, all the content was independently reviewed to check readability, as well as fidelity to the evidence-base.

A taxonomy was created to better describe each module. This included information on: category (what does the module focus on (e.g. mental health literacy, coping)); type (what does the module specifically focus on within the category (e.g. providing psychoeducation, teaching a self-help coping strategy)); method (how can the content be engaged with (e.g. imagery, writing, using senses, meditation, breathing, an activity, etc.)); targets (what "persona(s)" will benefit from the module); symptom (what problem(s) does the module aim to tackle); notification (whether the user receives notifications related to the module); and notification type (what does the notification ask of the user (e.g. learn more about a topic, engage in an exercise).

The third step was to design how content would be delivered to the user. Sentinel is a personalized DI as it asks users what goals they would like to prioritize (e.g., "Feel less anxious" or "Reduce stress")) and modifies content in line with this. It also adapts content according to a number of person-specific characteristics, including work environment and preferences of content (i.e., what content the user likes/does not like to engage with). Hence, it takes the user's individual circumstances and preferences into consideration when tailoring its content.

Across the user's journey, Sentinel also asks a series of questions to allow it to deduce what content users should be given to help deal with common problems associated with traumatic stress. For example, the user may be asked if they experience difficulties falling and staying asleep or recurring nightmares and be given sleep-related content depending on their answer. The app utilizes push-text notifications and reminders to increase and maintain user engagement (Saleem, et al, 2021). These notifications are delivered at regular intervals and are designed to boost a FR's overall wellbeing. Notifications also serve to reassess traumatic stress symptoms and maintain an adaptive personalized management approach. It is, therefore, possible for a user's "persona" to change as they use Sentinel.

**Phase 3:    User informed prototype refinement**

The third phase will involve initial testing of the prototype for the Sentinel application. We will conduct three co-creation video call sessions using Zoom and simulations of notice boards/post-its and

complemented with collective discussions. The time immediately after our co-creation meetings will be dedicated to our development "Sprints," to refine the Sentinel application. We have used this process previously in the development of digital health applications (Egan 2021). The first codesign session will present the principles of the Sentinel application and then demonstrate and critique a simple initial application prototype. The second codesign session will review the feedback from meeting 1 and progress during design sprint 1. The third codesign session will review and finalize the Sentinel application design in preparation for the pilot/feasibility study. If a participant cannot attend a group meeting, one-to-one calls will be offered as an alternative. We will recruit participants using convenience sampling (connections with first responder groups and previous survey/interview participants). We will aim to identify 6-8 participants for the co-creation groups to maximize the depth of conversation achievable with our discussions (Doria 2018). We will aim to include participants representing multistakeholder views across a variety of first responder groups including fire and emergency, police and emergency healthcare workers. Inclusion criteria will include participants aged 18 years and over and interested in contributing to current knowledge of digital innovations for trauma management in first responders. University Ethical approval will be obtained prior to the start of the study.

### Phase 4: Pilot Testing

The final phase will be a pilot test of Sentinel. This will involve assessing the efficacy of Sentinel on improving mental wellbeing, improving management of trauma and exploring participants' experiences of using Sentinel, with quantitative and qualitative data to be collected.

### Design

This is a mixed methods non-randomized study aimed at determining the feasibility, acceptability, safety, and usability of the Sentinel intervention. We aim to recruit a target sample of 60 FRs across diverse FR organizations. Participants aged 21 years and older who report distress associated exposure to work-related trauma(s) will be recruited from the National Health Service (NHS) in the UK and FR organizations. This sample size was shown to be sufficient to pilot test the feasibility and acceptability of an intervention of this nature. All participants will receive the Sentinel app for 6 weeks. Daily notifications will encourage FRs

to use the app, which is designed to be used in a stand-alone manner alongside routine care. We will follow participants up after the intervention and conduct interviews with stakeholders to explore the acceptability of the app and trial procedures, identify areas for improvement and explore routes toward implementation.

**Procedure**

Ethical approval will be obtained from the University Ethics Committee. Participants will be recruited through opportunity sampling via posters distributed within FR organizations, emails sent directly to FR staff members, and work intranet bulletin board advertisements. Interested participants will be eligible if they meet the following criteria: (i) aged between 21–65-years; (ii) full-time or part-time employee of a FR organization; (iii) understood the requirements of the study; and (iv) have no major mental illness that may impact on their capacity to consent to the trial.

Participants will first be asked to provide informed consent and then complete an online Qualtrics questionnaire including the trial outcomes measures. Following completion of the pre-intervention online questionnaire, participants will be provided with access to Sentinel and instructed to use the app for a 6-week period. Following the 6-week intervention period, participants will complete an online post-intervention questionnaire. An additional subset of FR participants ($n = 20$) will then be asked to take part in an audio-recorded one-to-one semi-structured interview to explore their experiences of using Sentinel. Further, healthcare professionals and service managers who referred FRs to the trial (n= 20) will be interviewed to explore the acceptability and usability of Sentinel. Participants will be selected according to a sampling framework to capture varied demographics, experiences of work-based trauma, and levels of engagement with the Sentinel app. Participant information sheets detailing the aims of the study and the participatory involvement of FRs in both the pilot trial and nested qualitative interviews will be developed and sent to prospective participants prior to gaining their informed consent. Additionally, participant information sheets will be developed and shared with healthcare workers and service managers referring FRs into the study prior to gaining their informed consent to take part in the nested interviews. We will explain to all potential participants that participation is voluntary and that they can withdraw their consent at any point during the study without providing a reason. It will be made clear to FRs that, as the intervention is not in place of standard care (it is in addition to standard care), withdrawal from the intervention will not impact their ability

The development and protocol for testing a co-created digital intervention (Sentinel) to improve mental wellbeing and help manage and prevent trauma in first responders

to continue to access standard care within the referring service or other sources of support they might access contemporaneously.

**Trial outcome measures**

**Demographics**

A series of demographics will be collected, including gender, age, ethnicity, health status, working status, and occupation.

**Primary Outcome Measures**

The Abbreviated Post-Traumatic Stress Disorder Checklist – Civilian (APCL-C; Lang & Stein, 2005) will be used to measure self-reported trauma symptoms. The APCL-C provides assessment for difficulties associated with post-traumatic stress in the civilian population. The 6-item APCL-C presents participants with common complaints in response to stressful life experiences and asks how frequently they have been bothered by each in the past month. Items include 'Repeated, disturbing memories, thoughts, or images of a stressful experience from the past' and 'Feeling irritable or having angry outbursts'. Responses are given on a 5-item Likert scale ranging from 1 (not at all) to 5 (extremely); here, higher scores are suggestive of difficulties with post-traumatic, acute stress which requires further professional attention. The measure is reported to have sound psychometric properties.

**Secondary Outcome Measures**

The Warwick-Edinburgh Wellbeing Scale (WEMWBS) will be used to subjectively measure mental wellbeing (Tennant et al, 2007). This scale has 14-items and is scored on 5-point scales (*1 = None of the time – 5 = All of the time)*, where higher scores indicate higher levels of mental wellbeing. WEMWBS has demonstrated both high internal consistency and high test-retest reliability Haver et al, 2015).

The Burnout Measure – Short Version (BMS-SV) is a 10-item scale designed to measure burnout across diverse occupational and community contexts. Participants will be asked how often they feel, for example, 'Tired', 'Worthless/Like a failure', 'I've had it'. Responses are given on a 7-point scale ranging from 1 (never) to 7 (always), where higher scores are associated with higher levels of physical, emotional, and mental burnout.

The Depression, Anxiety, and Stress Scale (DASS-21) will be used as a measure of mental health (Lovibond & Lovibond, 1995). It is a 21-item measure that is scored via 4-point scales (*0 = Did not apply at all – 3 = Applied to me very much, or most of the time)*, whereby higher scores reflect higher levels of distress. This measure calculates scores for depression, anxiety, and stress. Previous research has shown the DASS-21 to have good psychometric properties (Brown et al, 1997).

The Neuroception of Psychological Safety (NPSS; Morton et al., 2022) is a 29-item self-report measure that has three sub-scales (social engagement, compassion, and body sensations) and asks participants to rate how well statements describe their feelings over the past week. Statements include 'I felt valued', 'I felt compassion towards others' and 'My heartrate felt steady' and responses are given on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher scores on the NPSS indicate higher levels of psychological safety at the individual level. This measure has documented sound psychometric properties.

The Utrecht Work Engagement Scale (UWES) will be utilized to assess the extent to which participants report feeling positive, fulfilled, and in a work-related state of mind, characterized by vigor, dedication, and absorption (Schaufeli, et al, 2002). It is a 17-item measure scored via 7-point scales (*0 = Never – 6 = Always*), whereby higher scores exhibit higher levels of work engagement. The UWES calculates a total score plus 3 subscale scores, including: (i) vigor (i.e., high levels of energy, persistence, and resilience towards one's work activities), dedication (i.e., high levels of enthusiasm and investment in one's work, with a sense that it has meaning and purpose), and absorption (i.e., being fully and happily engrossed in one's work). This scale has documented high psychometric properties.

The Mobile App Rating Scale (MARS) will be used to classify and assess the quality of mobile health (mHealth) apps (Stoyanov, et al., 2015). The MARS has shown to be a reliable (Mani et al., 2015) and widely applied (Davalbhakta et al., 2020; Salazar et al., 2018) way to systematise assessment of the quality of mobile apps. The MARS includes 23 items grouped in different sections: engagement, functionality, aesthetics, information quality, and subjective quality.

The Post-traumatic Growth Short Form (Cann et al., 2010) is a measure that includes 10 items on a six-point Likert scale, where a score of zero indicates 'not at all' and a score of five indicates 'very much'; for example, 'I discovered that I am stronger than I thought I was'. This measure has been found to have good internal consistency and reliability (Leykinet et al, 2013).

The International Physical Activity Questionnaire short version (9 items) will be used to collect information on the time spent walking, in vigorous- and moderate-intensity activity and in sedentary activity. This questionnaire has been widely tested and designed to be used by adults aged 18–65 years (Craig et al, 2003).

## RESULTS

We expect data to be collected from up to 60 FRs. We expect to conduct approximately 20 qualitative interviews with FRs and 20 health and social care professionals who refer FRs to the study. We propose recruitment to commence in May 2024 and final data collection by December 2024. After final data analysis and the writing of the results, the manuscripts will be submitted to appropriate journals for dissemination, with the main findings published by December 2025. We expect to report results on (1) the number of eligible FR participants consenting; (2) the total number recruited, including information about recruitment setting to inform the sampling strategy of a future randomized trial; (3) completeness of outcome measures; (4) attrition rates and reasons for withdrawal; (5) the range of FR organizations offered Sentinel; (6) participant completion rates for Sentinel intervention; (7) Sentinel platform use and engagement analytics; and (8) safety of the Sentinel app and our trial procedures. We also expect to report on perceived barriers and enablers to integration and uptake into existing mental health care provider pathways.

## DISCUSSION

In this paper, we have, firstly, described the process for the development of the Sentinel digital application adopting a participatory co-creation approach and secondly, the protocol for determining the feasibility of the Sentinel trial and the acceptability, safety, and usability of the DI (Sentinel) and explore how to best integrate Sentinel into existing routine care pathways for FRs. We have emphasized the importance of FR user engagement and planning during all stages of the process. To the best of our

knowledge, this is the first DI to be co-created with FRs of this type in this population worldwide. We have carried out qualitative interviews with FRs, held regular advisory group meetings with key stakeholders, incorporated input and feedback from this work into the development of the app content and user interface, created content for the Sentinel app and developed a protocol for the pilot trial. The user-driven co-creation approach we have adopted is intended to ensure that the Sentinel intervention is engaging and relevant and reflects the experiences of FRs. The Sentinel digital application has the potential to provide many benefits, including: increased awareness of trauma and trauma related symptoms, accurate identification of primary and secondary trauma, immediate support for first responders and frontline workers, reduced costs/waiting times for therapy, counselling and referrals, early stage trauma management and prevention, remote triage leading to self-management, advanced stage sign-posting to healthcare professionals, and a unique and tailored experience based on sector, trauma type, data science, and AI.

Technology is leading to rapid change in the way mental health interventions are increasingly being delivered. In order to create inclusive opportunities for who experience mental health challenges (Cogan et al, 2021), associated with trauma, any DI development needs to not only address the present time but to anticipate and influence future technological directions (Morgan et al, 2020). In order to prevent current inequalities and biases becoming "hard wired" into DIs and algorithms for AI (Mohamed et al. 2020), it is essential that people with lived experiences of mental health challenges are involved in the co-production of such technologies. People with mental health challenges are one of several groups who are more likely to be digitally excluded (do not have access to or are unable to access the internet). Therefore, they may not have the opportunity to engage in DIs designed to support their mental health needs and experience further exclusion (Greer et al, 2019). Developments in technology to help support and treat people experiencing trauma are raising new ethical questions about the current and future rights of people accessing DIs, in particular their rights regarding surveillance, privacy and what it means to be human. In our work with Sentinel, we aim to consider such broader issues and continue strengthening our partnership working with FRs and other key stakeholders in our co-design process and future innovations.

**Limitations**

As this protocol is for a pilot study, we are unable to conclude whether the Sentinel intervention will bring about any clinically significant change post-intervention. However, this study design, with its focus on

feasibility, acceptability, safety, and usability, will provide valuable insights that will inform parameters for a future randomized trial, should this be indicated. Moreover, feedback from all stakeholders will allow for improvements in the Sentinel app, trial procedures, and plans for implementation. In our work, to date, we have not yet engaged with military FRs; we would view this as a priority in our next steps in DI development.

## CONCLUSIONS

We have demonstrated the utility of the co-creation process to develop a novel approach to developing Sentinel, a personalized digital app for FRs. Further work is now required to explore the acceptability, usability, feasibility and safety of this app across diverse FR service settings. This process will help us understand how best to develop a DI for FRs that helps harness the potential positive aspects of Sentinel in improving the management of trauma and its prevention but also reduce any potential concerns or safety issues that may serve as a barrier to engagement with DIs. This feasibility trial stands to advance the support for FRs, an essential area for both research and intervention development. Pilot testing our Sentinel DI is the first step in creating a more definitive intervention that may be further tested in future studies and implemented to support FRs across a range of service settings.

## REFERENCES

AbiNader, M. A., Messing, J. T., Pizarro, J., Kappas Mazzio, A., Turner, B. G., & Tomlinson, L. (2023). Attending to our own trauma: Promoting vicarious resilience and preventing vicarious traumatization among researchers. *Social Work Research*, *47*(4), 237-249.

Alden, L.E., Matthews, L.R., Wagner, S., Fyfe, T., Randall, C., Regehr, C., et al. (2020). Systematic literature review of psychological interventions for first responders. *Work & Stress, 35,* 1–23. https://doi.org/10.1080/02678373.2020.1758833

Alshehri, F. F., Alghamdi, S. A., Alrashoudi, A. M., Albednah, F. A., Alotaibi, A. B., Alojayri, A. M., ... & Alojayri Sr, A. M. (2023). Post-traumatic stress disorder and its associated risk factors among emergency healthcare workers: a Saudi cross-sectional analytical study. *Cureus*, *15*(8), e44327. doi: 10.7759/cureus.44327

The development and protocol for testing a co-created digital intervention (Sentinel) to improve mental wellbeing and help manage and prevent trauma in first responders

Auth, N. M., Booker, M. J., Wild, J., & Riley, R. (2022). Mental health and help seeking among trauma-exposed emergency service staff: a qualitative evidence synthesis. *BMJ Open*, 12(2), e047814. doi:10.1136/bmjopen-2020-047814

Back, C. Y., Hyun, D. S., Chang, S. J., & Jeung, D. Y. (2023). Trauma Exposure and Suicidal Ideation among Korean Male Firefighters: Examining the Moderating Roles of Organizational Climate. *Safety and Health at Work*, *14*(1), 71-77. doi: 10.1016/j.shaw.2022.11.005

Beauchamp, A. M., & Jetelina, K. K. (2022). Effects of social and occupational stress, and physical strain on suicidal ideation among law enforcement officers. *Occupational Health Science*, 1-17. https://doi.org/10.1007/s41542-021-00103-7

Berger, W., Coutinho, E. S. F., Figueira, I., Marques-Portella, C., Luz, M. P., Neylan, T. C., Marmar, C. R., & Mendlowicz, M. V. (2012). Rescuers at risk: A systematic review and meta-regression analysis of the worldwide current prevalence and correlates of PTSD in rescue workers. *Social Psychiatry and Psychiatric Epidemiology*, 47(6), 1001–1011. https://doi.org/10.1007/s00127- 011-0408-2

Blake, H., Bermingham, F., Johnson, G., & Tabner, A. (2020). Mitigating the psychological impact of COVID-19 on healthcare workers: a digital learning package. *International Journal of Environmental Research and Public Health*, *17*(9), 2997. https://doi.org/10.3390/ijerph17092997

Bisson, J. I., & Olff, M. (2021). Prevention and treatment of PTSD: the current evidence base. *European Journal of Psychotraumatology*, *12*(1), 1824381. doi: 10.1080/20008198.2020.1824381

Boffa, J. W., Stanley, I. E., Horn, M. A., Norr, A. M., Joiner, T. E., & Schmidt, N. B. (2017). PTSD symptoms and suicidal thoughts and behaviors among firefighters. *Journal of Psychiatric Research*, 84, 277–283. https://doi.org/10.1016/j.jpsychires.2016.10.014

Borghouts, J., Eikey, E., Mark, G., De Leon, C., Schueller, S. M., Schneider, M., ... & Sorkin, D. H. (2021). Barriers to and facilitators of user engagement with digital mental health interventions: systematic review. *Journal of Medical Internet Research*, *23*(3), e24387. doi: 10.2196/24387.

Brown, T. A., Chorpita, B. F., Korotitsch, W., & Barlow, D. H. (1997). Psychometric properties of the Depression Anxiety Stress Scales (DASS) in clinical samples. *Behavior Research and Therapy*, *35*(1), 79-89. doi: 10.1016/s0005-7967(96)00068-x.

Brown, L. S., & Courtois, C. A. (2019). Trauma treatment: The need for ongoing innovation. *Practice Innovations*, *4*(3), 133. https://doi.org/10.1037/pri0000097

Bryant, R. A. (2022). Early intervention after trauma. *Evidence based treatments for trauma-related psychological disorders: A practical guide for clinicians*, 135-159. DOI:10.1007/978-3-319-07109-1

Cann, A., Calhoun, L. G., Tedeschi, R. G., Taku, K., Vishnevsky, T., Triplett, K. N., & Danhauer, S. C. (2010). A short form of the Posttraumatic Growth Inventory. *Anxiety, Stress, & Coping*, *23*(2), 127-137. doi: 10.1080/10615800903094273.

Casas, J. B., & Benuto, L. T. (2022). Breaking the silence: A qualitative analysis of trauma narratives submitted online by first responders. *Psychological Trauma: Theory, Research, Practice, and Policy, 14*(2), 190–198. https://doi.org/10.1037/tra0001072

Chen, J. X., McDonald, A., Zou, Y., Tseng, E., Roundy, K. A., Tamersoy, A., ... & Dell, N. (2022, April). Trauma-informed computing: Towards safer technology experiences for all. In *Proceedings of the 2022 CHI conference on human factors in computing systems* (pp. 1-20). https://doi.org/10.1145/3491102.3517475

Clark, L. V., Fida, R., Skinner, J., Murdoch, J., Rees, N., Williams, J., ... & Sanderson, K. (2021). Mental health, well-being and support interventions for UK ambulance services staff: an evidence map, 2000 to 2020. *British Paramedic Journal*, 5(4), 25-39. doi: 10.29045/14784726.2021.3.5.4.25.

Cogan, N., Kennedy, C., Beck, Z., McInnes, L., MacIntyre, G., Morton, L., ... & Kolacz, J. (2022). ENACT study: What has helped health and social care workers maintain their mental well-being during the COVID-19 pandemic?. *Health & Social Care in the Community*, *30*(6), e6656-e6673. https://doi.org/10.1111/hsc.13992

Cogan, N., & MacDonald, A. (2021). The importance of adaptive coping, peer support, psychological input, team resilience, and supportive management among fire and rescue service workers in maintaining wellbeing throughout the COVID-19 pandemic: a cross-sectional survey. *The Lancet*, *398*, S34. https://doi.org/10.1016/S0140-6736(21)02577-0

Cogan, N. A., MacIntyre, G., Stewart, A., Tofts, A., Quinn, N., Johnston, G., ... & Rowe, M. (2021). "The biggest barrier is to inclusion itself": the experience of citizenship for adults with mental health problems. *Journal of Mental Health*, *30*(3), 358-365.

Craig, C.L., Marshall, A.L., Sjöström, M., Bauman, A.E., Booth, M.L., Ainsworth, B.E, … & Oja, P. (2003) International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exer,* 35(8),1381-95. doi: 10.1249/01.MSS.0000078924.61453.FB.

Dana, D. (2018). *The Polyvagal theory in therapy: engaging the rhythm of regulation (Norton series on interpersonal neurobiology)*. WW Norton & Company.

Davalbhakta, S., Advani, S., Kumar, S., Agarwal, V., Bhoyar, S., Fedirko, E., ... & Agarwal, V. (2020). A systematic review of smartphone applications available for corona virus disease 2019 (COVID19) and the assessment of their quality using the mobile application rating scale (MARS). *Journal of Medical Systems*, *44*, 1-15. doi: 10.1007/s10916-020-01633-3

Doria, N., Condran, B., Boulos, L., Curtis Maillet, D. G., Dowling, L., & Levy, A. (2018). Sharpening the focus: differentiating between focus groups for patient engagement vs. qualitative research. *Research Involvement and Engagement*, *4*(1), 1-8. https://doi.org/10.1186/s40900-018-0102-6

Drew, J. M., & Martin, S. (2021). A national study of police mental health in the USA: stigma, mental health and help-seeking behaviors. *Journal of Police and Criminal Psychology*, *36*(2), 295-306. https://doi.org/10.1007/s11896-020-09424-9

Egan, K. J., Hodgson, W., Dunlop, M. D., Imperatore, G., Kirk, A., & Maguire, R. (2021). A Novel Mobile App ("CareFit") to Support Informal Caregivers to Undertake Regular Physical Activity From Home During

The development and protocol for testing a co-created digital intervention (Sentinel) to improve mental wellbeing and help manage and prevent trauma in first responders

and Beyond COVID-19 Restrictions: Co-design and Prototype Development Study. *JMIR Formative Research*, *5*(10), e27358. https://doi.org/10.2196/27358

Forneris, C. A., Gartlehner, G., Brownley, K. A., Gaynes, B. N., Sonis, J., Coker-Schwimmer, E., ... & Lohr, K. N. (2013). Interventions to prevent post-traumatic stress disorder: a systematic review. *American Journal of Preventive Medicine*, *44*(6), 635-650.

Geuzinge, R., Visse, M., Duyndam, J., & Vermetten, E. (2020). Social embeddedness of firefighters, paramedics, specialized nurses, police officers, and military personnel: Systematic review in relation to the risk of traumatization. *Frontiers in Psychiatry*, *11*, 496663. doi: 10.3389/fpsyt.2020.496663

Greer, B., Robotham, D., Simblett, S., Curtis, H., Griffiths, H., & Wykes, T. (2019). Digital exclusion among mental health service users: qualitative investigation. *Journal of Medical Internet Research*, *21*(1), e11696.

Griffith, B., Archbold, H., Sáez Berruga, I., Smith, S., Deakin, K., Cogan, N., ... & Flowers, P. (2023). Frontline experiences of delivering remote mental health supports during the COVID-19 pandemic in Scotland: innovations, insights and lessons learned from mental health workers. *Psychology, Health & Medicine*, *28*(4), 964-979. https://doi.org/10.1080/13548506.2022.2148698

Hamblen, J. L., Norman, S. B., Sonis, J. H., Phelps, A. J., Bisson, J. I., Nunes, V. D., ... & Schnurr, P. P. (2019). A guide to guidelines for the treatment of posttraumatic stress disorder in adults: An update. *Psychotherapy*, *56*(3), 359. doi: 10.1037/pst0000231.

Haugen, P. T., Evces, M., & Weiss, D. L. (2012). Treatment posttraumatic stress disorder in first responders: A systematic review. *Clinical Psychology Review*, 32(5), 370–380. https://doi.org/ 10.1016/j.cpr.2012.04.001

Haver, A., Akerjordet, K., Caputi, P., Furunes, T., & Magee, C. (2015). Measuring mental well-being: A validation of the short Warwick–Edinburgh mental well-being scale in Norwegian and Swedish. *Scandinavian Journal of Public Health*, *43*(7), 721-727. doi: 10.1177/1403494815588862.

Isobel, S. (2021). Trauma-informed qualitative research: Some methodological and practical considerations. *International Journal of Mental Health Nursing*, *30*, 1456-1469. https://doi.org/10.1111/inm.12914

Johnson, C. C., Vega, L., Kohalmi, A. L., Roth, J. C., Howell, B. R., & Van Hasselt, V. B. (2020). Enhancing mental health treatment for the firefighter population: Understanding fire culture, treatment

barriers, practice implications, and research directions. *Professional Psychology: Research and Practice, 51*(3), 304–311. https://doi.org/10.1037/pro0000266

Jones, S., Agud, K., & McSweeney, J. (2020). Barriers and facilitators to seeking mental health care among first responders: "removing the darkness". *Journal of the American Psychiatric Nurses Association*, *26*(1), 43-54. doi: 10.1177/1078390319871997.

Kim, W., Bae, M., Chang, S. J., Yoon, J. H., Hyun, D. S., Ryu, H. Y., ... & Kim, C. (2019). Effect of burnout on post-traumatic stress disorder symptoms among firefighters in Korea: Data from the Firefighter Research on Enhancement of Safety & Health (FRESH). *Journal of Preventive Medicine and Public Health*, *52*(6), 345. doi: 10.3961/jpmph.19.116.

Klimley, K. E., Van Hasselt, V. B., & Stripling, A. M. (2018). Posttraumatic stress disorder in police, firefighters, and emergency dispatchers. *Aggression and Violent Behavior*, *43*, 33-44. https://doi.org/10.1016/j.avb.2018.08.005

Knobloch, L. K., & Owens, J. L. (2023). Assessing the REBOOT First Responders program: Physical, mental, and social health outcomes. *Traumatology, 29*(1), 76–86. https://doi.org/10.1037/trm0000366

Krantz, D. S., Shank, L. M., & Goodie, J. L. (2022). Post-traumatic stress disorder (PTSD) as a systemic disorder: Pathways to cardiovascular disease. *Health Psychology*, *41*(10), 651. https://doi.org/10.1016/j.avb.2018.08.005

Lemer, V. (2018). The increasing role of digital technologies in co-production and co-creation. In *Co-production and co-creation* (pp. 115-127). Routledge. DOI:10.4324/9781315204956-16

Lewis, C., Roberts, N. P., Andrew, M., Starling, E., & Bisson, J. I. (2020). Psychological therapies for post-traumatic stress disorder in adults: Systematic review and meta-analysis. *European Journal of Psychotraumatology*, *11*(1), 1729633. doi: 10.1080/20008198.2020.1729633

Lovibond, S. H., & Lovibond, P. F. (1995). Manual for the Depression Anxiety Stress Scale. Sydney: The Psychological Foundation of Australia, Inc. https://doi.org/10.1037/t01004-000

MacIntyre, G., Cogan, N., Stewart, A., Quinn, N., Rowe, M., & O'Connell, M. (2018). Understanding citizenship within a health and social care context in Scotland using community based participatory research methods. *SAGE Research Methods Cases*. DOI:10.4135/9781526484918

Meckes, S. J., McDonald, M. A., & Lancaster, C. L. (2021). Association between physical activity and mental health among first responders with different service roles. *Psychological Trauma: Theory, Research, Practice, and Policy, 13*(1), 66–74. https://doi.org/10.1037/tra0000971

Michie, S., Yardley, L., West, R., Patrick, K., & Greaves, F. (2017). Developing and evaluating digital interventions to promote behavior change in health and health care: recommendations resulting from an international workshop. *Journal of Medical Internet Research*, *19*(6), e232. doi: 10.2196/jmir.7126

Mohamed, S., Png, M.T. and Isaac, W., 2020. Decolonial AI: decolonial theory as sociotechnical foresight in artificial intelligence. *Philosophy & Technology*, *33*, pp.659-684.

Morton, L., Cogan, N., Kolacz, J., Calderwood, C., Nikolic, M., Bacon, T., ... & Porges, S. W. (2022). A new measure of feeling safe: Developing psychometric properties of the Neuroception of Psychological Safety Scale (NPSS). *Psychological Trauma: Theory, Research, Practice, and Policy*. https://doi.org/10.1037/tra0001313

Motta, R. W. (2023). Social Support and Secondary Trauma. In *Secondary Trauma: Silent Suffering and Its Treatment* (pp. 75-82). Cham: Springer Nature Switzerland.

Morgan, P., Brannelly, T. and Eales, S., 2020. Future studies, mental health and the question of citizenship. *Mental Health and Social Inclusion*, *24*(1), pp.23-32.

NHS Education for Scotland. (2017). Transforming psychological trauma: A knowledge and skills framework for the Scottish Workforce.

Newell, C. J., Ricciardelli, R., Czarnuch, S. M., & Martin, K. (2022). Police staff and mental health: Barriers and recommendations for improving help-seeking. *Police Practice and Research*, *23*(1), 111-124.

Pines, A. M. (2005). The burnout measure short version (BMS). *International Journal of Stress Management*, *12*(1), 78-88. DOI:10.1080/15614263.2021.1979398

The development and protect for testing a co-created digital intervention (Sentinel) to improve mental wellbeing and help manage and prevent trauma in first responders

Porges, S. W. (2022). Polyvagal theory: a science of safety. *Frontiers in Integrative Neuroscience*, *16*, 27. https://doi.org/10.3389/fnint.2022.871227

Qi, W., Gevonden, M., & Shalev, A. (2016). Prevention of post-traumatic stress disorder after trauma: current evidence and future directions. *Current Psychiatry Reports*, *18*, 1-11. DOI: 10.1007/s11920-015-0655-0

Ruzek, J. I., & Yeager, C. M. (2017). Internet and mobile technologies: addressing the mental health of trauma survivors in less resourced communities. *Global Mental Health*, *4*, e16. doi: 10.1017/gmh.2017.11.

Salazar, A., de Sola, H., Failde, I., & Moral-Munoz, J. A. (2018). Measuring the quality of mobile apps for the management of pain: systematic search and evaluation using the mobile app rating scale. *JMIR mHealth and uHealth*, *6*(10), e10718. doi: 10.2196/10718

Saleem, M., Kühne, L., De Santis, K. K., Christianson, L., Brand, T., & Busse, H. (2021). Understanding engagement strategies in digital interventions for mental health promotion: scoping review. *JMIR Mental Health*, *8*(12), e30000. doi: 10.2196/30000.

Schaufeli, W. B., Salanova, M., González-Romá, V., & Bakker, A. B. (2002). The measurement of engagement and burnout: A two sample confirmatory factor analytic approach. *Journal of Happiness Studies, 3*, 71–92. doi:10.1023/A:1015630930326.

Smith, A. & Roberts, K. (2003). Interventions for post-traumatic stress disorder and psychological distress in emergency ambulance personnel: a review of the literature. Emergency Medicine Journal. 2003; 20(1):75–8. https://doi.org/10.1136/emj.20.1.75 PMID: 12533381

Smith, E., Pooley, J. A., Holmes, L., Gebbie, K., & Gershon, R. (2023). Vicarious trauma: Exploring the experiences of qualitative researchers who study traumatized populations. *Disaster Medicine and Public Health Preparedness*, *17*, e69. doi: 10.1017/dmp.2021.333.

Somville, F., Van Bogaert, P., Wellens, B., De Cauwer, H., & Franck, E. (2023). Work stress and burnout among emergency physicians: a systematic review of last 10 years of research. *Acta Clinica Belgica*, 1-10. doi: 10.1080/17843286.2023.2273611.

Stoyanov, S. R., Hides, L., Kavanagh, D. J., Zelenko, O., Tjondronegoro, D., & Mani, M. (2015). Mobile app rating scale: a new tool for assessing the quality of health mobile apps. *JMIR mHealth and uHealth*, *3*(1), e3422. doi: 10.2196/mhealth.3422.

Tan, L., Deady, M., Bryant, R. A., & Harvey, S. B. (2023). Adaptive and maladaptive cognitive-emotional strategies associated with PTSD in first responders: A cross-sectional study. *Journal of Occupational and Environmental Medicine*, *65*(6), e372-e377. doi: 10.1097/JOM.0000000000002829.

Taylor, C. B., Ruzek, J. I., Fitzsimmons-Craft, E. E., Sadeh-Sharvit, S., Topooco, N., Weissman, R. S., ... & Oldenburg, B. (2020). Using digital technology to reduce the prevalence of mental health disorders in populations: time for a new approach. *Journal of Medical Internet Research*, *22*(7), e17493. doi: 10.2196/17493

Tennant, R., Hiller, L., Fishwick, R., Platt, S., Joseph, S., Weich, S., ... & Stewart-Brown, S. (2007). The Warwick-Edinburgh mental well-being scale (WEMWBS): development and UK validation. *Health and Quality of life Outcomes*, *5*(1), 1-13. doi:10.1186/1477-7525-5-63

Wallerstein, N., & Duran, B. (2010). Community-based participatory research contributions to intervention research: the intersection of science and practice to improve health equity. *American Journal of Public Health*, *100*(S1), S40-S46. doi: 10.2105/AJPH.2009.184036

Whealin, J. M., Ruzek, J. I., & Southwick, S. (2008). Cognitive–behavioral theory and preparation for professionals at risk for trauma exposure. *Trauma, Violence, & Abuse*, *9*(2), 100-113. DOI: 10.1177/1524838008315869

Wickersham, A., Petrides, P. M., Williamson, V., & Leightley, D. (2019). Efficacy of mobile application interventions for the treatment of post-traumatic stress disorder: a systematic review. *Digital Health*, *5*, 2055207619842986. doi: 10.1177/2055207619842986.

Williams, S. D., & Williams, J. (2020). Posttraumatic stress in organizations: Types, antecedents, and consequences. *Business and Society Review*, *125*(1), 23-40. https://doi.org/10.1111/basr.12192

Winders, W. T., Bustamante, N. D., Garbern, S. C., Bills, C., Coker, A., Trehan, I., ... & Levine, A. C. (2021). Establishing the effectiveness of interventions provided to first responders to prevent and/or treat

mental health effects of response to a disaster: a systematic review. *Disaster Medicine and Public Health Preparedness,* 15(1), 115-126. doi: 10.1017/dmp.2019.140.

Wong, R. (2021). Guidelines to Incorporate Trauma-Informed Care Strategies in Qualitative Research. Retrieved December 5, 2023 from https://www.urban.org/urban-wire/guidelines-incorporate-trauma-informed-care-strategies-qualitative-research

Yardley, L., Morrison, L., Bradbury, K., & Muller, I. (2015). The person-based approach to intervention development: application to digital health-related behavior change interventions. *Journal of Medical Internet Research*, *17*(1), e4055. doi: 10.2196/jmir.4055.

Yoon, S., Goh, H., Nadarajan, G. D., Sung, S., Teo, I., Lee, J., ... & Teo, T. L. (2021). Perceptions of mobile health apps and features to support psychosocial well-being among frontline health care workers involved in the COVID-19 pandemic response: qualitative study. *Journal of Medical Internet Research*, *23*(5), e26282. doi: 10.2196/26282.

Zolnikov, T. R., & Furio, F. (2020). Stigma on first responders during COVID-19. *Stigma and Health, 5*(4), 375–379. https://doi.org/10.1037/sah0000270

Conflict of interest statement