




# BMJ Open Study protocol: how does parental stress measured by clinical scales and voice acoustic stress markers predict children's response to PTSD trauma-focused therapies?

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## ABSTRACT

**Introduction** Post-traumatic stress disorder (PTSD) symptoms in youth are influenced by parental anxiety and stress. When parents have high levels of stress or have developed PTSD themselves, children tend to show more anxiety symptoms. Parental stress can affect the severity of children's PTSD and lower the success of recovery. However, the influence of parental stress on the effectiveness of trauma-focused therapies (eye movement desensitisation and reprocessing and cognitive behavioural therapy) has not yet been investigated to our knowledge. Hence, we will measure parental stress (using both validated scales and vocal acoustic markers) and investigate how it influences children's PTSD recovery.

**Method and analysis** Sixty children between the ages of 7 and 15 years who experienced type 1 trauma will be recruited at the Nice Pediatric Psychotrauma Center in France. We plan to measure stress using two different approaches. We will ask parents to answer validated scales of stress and mood in general. Stress will also be measured using vocal acoustic markers. Parents will be recorded while narrating their child's trauma and during the narrative of a positive and neutral recall of events. Child participants will have to complete anxiety, PTSD and depression scales before the beginning of the trauma-focused therapy and after 3 months of treatment. Linear mixed effects models and differential statistics, such as significance testing corrected for multiple testing, will be used to determine the validity of speech features for the proposed hypotheses. Repeated measures analysis of variance will be performed on the clinical scales scores according to parental stress. Correlations will be performed between clinical scales of parents and children according to time of assessment.

**Ethics and dissemination** This study was approved by the Committee for the Protection of Individuals of the University of Nice Sophia Antipolis (CERNI) on 21 February 2022, under the number CER2022-015.

All participants will be informed that this is an observational study and their consent taken prior to the experiment. Participants will be informed that they can withdraw from the study at any time and that it would not affect the care provided.

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Using a combination of validated tools and new technologies to identify parental stress.
- ⇒ Consideration of family dynamics in therapeutic responses to children.
- ⇒ Lack of evaluation of parental treatment (pharmacological and non-pharmacological).
- ⇒ No control group in this study was included.

**Trial registration number** CER AVIS n° 2022-015.

## INTRODUCTION

Post-traumatic stress disorder (PTSD) is a condition that can develop after experiencing a potentially traumatic event.<sup>1</sup> In the Diagnostic and Statistical Manual of Mental Disorders, Fifth edition (DSM-5),<sup>2</sup> PTSD is characterised by four symptoms:

- Re-experiencing (intrusive memories of the traumatic event, emotional distress if an external reminder, etc).
- Avoidance (eg, avoidance of thoughts, emotions, situations, conversations, places).
- Cognitive/mood alterations (hopelessness, detachment from family and friends, lack of interest in activities usually enjoyed, emotional numbness, etc).
- Neurovegetative overactivation (eg, easily startled, alert, trouble sleeping and/or concentrating, irritability and/or aggressive behaviour).

The prevalence of PTSD among children and adolescents, who have experienced a traumatic event, is estimated at 15.9%<sup>3</sup> but can vary depending on the type of trauma. The prevalence of PTSD in case of road traffic accident is estimated at 20%<sup>4</sup> but can

reach 40% in the case of sexual assault,<sup>5</sup> terrorist attack or exposure to war.<sup>6</sup>

### Parental stress

Several factors have been identified as increasing the risk of PTSD severity.<sup>1</sup> These include parents' stress and psychiatric disorders.<sup>7</sup> Indeed, parents can also develop a pathological condition during traumatic events experienced by their children. The percentage of vicarious trauma in parents is estimated at around 15% in cases of single trauma.<sup>8,9</sup> For example, the prevalence of PTSD at 6 months in parents of children who have experienced a motor vehicle accident is around 10%.<sup>10</sup> However, the prevalence of full or partial PTSD is estimated at 15%.<sup>11</sup> In cases of medical trauma, this percentage increases to 18%.<sup>12</sup> These symptoms generate an alteration in the daily functioning of parents<sup>13</sup> and are maintained over time in the absence of treatment.<sup>14</sup>

Parental PTSD affects the children's functioning, both in the short-term and long-term.<sup>15</sup> Studies have highlighted the influence of parental PTSD, particularly on the maternal side in the development and severity of child PTSD.<sup>16,17</sup> Parental PTSD increases the risk of PTSD in children, resulting in the persistency of their symptomatology.<sup>18,19</sup> There is a greater severity of PTSD symptoms in children and a reduced chance of recovery.<sup>20</sup>

More widely, pediatric PTSD symptoms are influenced by parental anxiety and stress. Some studies show that when parents have high levels of stress or have developed PTSD themselves, children tend to show more anxiety symptoms.<sup>21</sup> In a similar way, parental stress also seems to influence the maintenance of children's symptoms, making therapies less effective. However, these studies do not use therapeutic protocols specific to PTSD, such as trauma-focused cognitive behavioural therapy (TF-CBT) or eye movement desensitisation and reprocessing (EMDR). TF-CBT and EMDR are both effective therapies in reducing trauma symptoms and externalising behaviour problems in children and adolescents.<sup>22-24</sup> A meta-analysis has shown equal effectiveness between TF-CBT and EMDR<sup>25</sup> although a more recent meta-analysis has shown greater effectiveness from TF-CBT than EMDR.<sup>23</sup> Effectiveness was found greater in older adolescents.<sup>22</sup> Parental stress is usually measured by specific questionnaires such as the Parental Stress Index<sup>26</sup> or semi-structured interviews.

### Acoustic voice stress markers

One method may be to use voice as a reflection of the individual's stress and anxiety state.<sup>27</sup> Indeed, markers have been identified in the voice in individuals with psychological stress.<sup>28,29</sup> Questionnaires are today still the gold standard for assessing stress levels allowing capturing different subsymptoms. However, it remains highly subjective and is limited to a punctual assessment, which is not systematically completed in clinical routine practice since it also represents an additional burden to patient.

Paradoxically, stress-related symptoms are often under-reported in certain fragile populations but potentially detectable through passive monitoring of changes in speech behaviour. For instance, studies have shown that voice analysis can help to detect subtle signs of depression or anxiety.<sup>30-33</sup> Thus, the detection of subtle events in the voice may offer a window into assessing the impact of stress in a passive non-intrusive way during routine clinical practice. The use of automatic extraction of stress markers could help improve the detection of parental stress in a more objective and finer way.

Studies have highlighted that stress affects language production (phrasing and grammar) but also prosody.<sup>34,35</sup> Stress can also increase muscle tension and respiratory rate, which consequently changes the mechanics of speech production.<sup>36,37</sup> Thus, disturbances in voice could be used as markers to identify individuals at risk for anxiety-related pathologies and more broadly an indicator of individuals' mental health.<sup>38,39</sup>

Moreover, the impact of voice on mental states has been investigated extensively and studies have shown that maternal voice, like physical touch, reduces cortisol, which generally increases in stressful situations.<sup>40</sup> Hearing a mother's voice also increases levels of oxytocin, which is linked to phenomena such as mother-infant attachment.<sup>41</sup> These effects are due to the prosody of the mother's voice rather than to the linguistic content.<sup>42</sup>

Recent advances in natural language processing and acoustic speech analysis have shown promising diagnostic relevance in identifying emotional speech, having direct applications for major depressive disorder and PTSD.<sup>43,44</sup> Prosodic, formant, source and temporal features can be extracted from the acoustic signal. As stress can disturb breathing patterns, temporal features related to speech periods length, pauses, speech durations,<sup>45</sup> speech rate<sup>46</sup> can be extracted. The main prosodic feature related to fold vibration is the fundamental frequency or F0 (number of cycles per second of a sound wave). Other indicators of stress could be extracted such as articulatory perturbations using formants that gives information regarding the functioning of the vocal tract and the laryngeal muscle system or the cycle or the increase of breathiness of the voice using glottal waveform of a vowel.<sup>47</sup> Decreased Jitter in emergency situations have been reported.

Recently, voice speech analyses was conducted on patients with PTSD and controls to differentiate the two groups.<sup>48</sup> Authors showed that the probability of having a PTSD was higher with vocal markers related to a more monotonous voice and a slower speech.

### Ethical and dissemination

This study was approved by the Committee for the Protection of Individuals of the University of Nice Sophia Antipolis (CERNI) on 21 February 2022, under the number CER2022-015.

Participants will be informed that the study is observational. The assessments and treatment are part of a classical evaluation and care. Participants are informed that

they can withdraw from the study at any time and that it would not affect the care provided.

There are no expected risks or burdens to participants. Consent will be taken prior to the experiment and all participants will be informed that this is an observational study and their consent taken prior to the experiment. Results from this study will be published in peer-reviewed journals. All communications will only include processed and non-identifiable data.

### Objectives and hypothesis

Therefore, the first objective of this study is to explore if parental stress may be a predictor of the children's response to trauma-focused therapies: CBT (cognitive behavioural therapy) or EMDR (eye movement desensitisation and reprocessing). Parental stress will be measured using specific clinical scales; the Parental Stress Inventory (PSI), Parental Sense of Competence Scale (PSOC) and the State-Trait Anxiety Inventory (STAI) scales. Parental stress will be analysed in the voice during the trauma narrative using automatic speech analysis.

The second objective is to assess whether PTSD and depression parental symptoms also have a modulating effect on children's response to trauma-focused therapies.

The main hypothesis of this study is that parental stress can influence the child's responses to specific therapies, whether CBT or EMDR. Children of parents with anxiety, depression or PTSD symptoms should show more PTSD symptoms after the 3 months period of treatment than children with symptom-free parents. In addition, parental stress voice markers should correlate positively with the PTSD symptoms of children after therapy.

## METHODS AND MATERIAL

### Participants

Participants will be recruited from the Nice Pediatric Psychotrauma Center (NPPC) at the Children's University Hospitals of Nice, France. The NPPC is a multidisciplinary centre dedicated to psychotrauma assessment and specific care for children and adolescents exhibiting psychological and psychiatric symptoms after experiencing a traumatic event.

Sixty patients aged from 7 to 15 years old will be recruited with their parents. They must have experienced a type 1 trauma (single experience: road accident, physical or sexual assault, fire, etc) and require specific treatment for trauma (TF-CBT or EMDR).

Patients who suffered from a type 2 trauma (repeated traumatic experience), or complex PTSD (ie, migratory journey and intrafamily violence) will not be included. Patients with complex disorders (eg, autism spectrum, psychosis, intellectual disabilities, patients with pharmacological treatments) will not be included. Non-French speakers will not be included as they would not be able to complete questionnaires.

Exclusion criteria are as follows: (1) the investigator's decision to discontinue the subject's participation in the

study (discovery of a complex disorder); (2) by the participant's decision to withdraw from the study.

First inclusions started 6 May 2022 and will continue over a period of 24 months. Currently five children and their parents have been included.

### Patient and public involvement

Patients were not involved in the development of the protocol.

### Procedure and clinical assessment

The protocol phases are represented in [table 1](#). During a first appointment, the study will be explained to the parents and their child. Informed consents are then collected from the parent that is participating in the study and the child. The parent included in the study is the one in charge to bring the child to the psychological appointments in the centre.

During the second appointment, parents will recall a neutral and the traumatic events of their child. Their speech will be recorded to extract acoustic speech features. Clinical assessments will be conducted during that appointment as well. Depression symptoms will be assessed using the Beck Depression Inventory (BDI, 5 min;<sup>49</sup>). PTSD will be evaluated using the PTSD Checklist 5 (PCL-5, 10–15 min;<sup>50</sup>). Parental skills and stress will be assessed, respectively, using the Parent Sense Of Competence (PSOC;<sup>51</sup>) and the Parental Stress Index (PSI, 15 min;<sup>26</sup>). At the same time, children will complete the self-questionnaires to assess depression and anxiety using the Revised Child Anxiety and Depression Scale (RCADS, 15 min;<sup>52 53</sup>) and the Child PTSD Checklist (CPC children, 15 min;<sup>54 55</sup>).

Phase A: Speech recording of the parent recalling the child's traumatic event (5–15 min) and neutral and positive events (5–15 min for each). Clinical assessment of the symptoms will be completed for both the child and their parent.

Phase B: For a period of 3 months, the participant will be in the care of psychologists specialised in EMDR or CBT for children. The appointments will be weekly. This phase corresponds to what is proposed within the framework of the therapeutic follow-up of the hospital unit.

Phase C: At the end of the 3-month period of treatment, phase A will be repeated in the same way: speech recording, evaluation of parental and child symptoms.

### Clinical scales

All clinical scales included in the study were validated in specific populations (children or adults) and in the French language. Reliability and validity were tested in validation studies.

Child PTSD Checklist (CPC) child version<sup>54 55</sup>: This questionnaire assesses PTSD symptoms during the last 15 days. Thirteen questions are related to traumatic events. It comprises 20 questions to evaluate the intensity of PTSD symptoms over the last 15 days. A score greater than 20 is considered as a probable PTSD diagnosis.

**Table 1** Protocol overview

Study phases	Description				
Phase A : Informed consent collection and assessments	<ol style="list-style-type: none"> <li>Two psychologists will receive the child participant and their parent who accepted to participate.</li> <li>Short introduction about the procedure and the aim of the study.</li> <li>Informed consent will be collected from both child and parent.</li> <li>Both parent and children are received by a psychologist separately.</li> </ol>				
	<table border="0"> <tr> <td style="text-align: center;">Parent</td> <td style="text-align: center;">Child</td> </tr> <tr> <td> <ol style="list-style-type: none"> <li>Neutral question: « Could you recall a typical/classical day of your child? » (audio recording).</li> <li>Questionnaires completion: STAI, BDI PCL.</li> <li>The traumatic event question: « Could you recall what happened to your child? » (audio recording).</li> <li>Subjective stress evaluation following the recall of the traumatic event: was the telling stressful to you? From a scale from 1 being not stressful at all, to 7 being very stressful, could you tell me how stressful it was for you? »</li> <li>Questionnaires completion: PSI, PSOC.</li> <li>Positive question: 'Could you tell me a positive event of your life?' (audio recording).</li> </ol> </td> <td> <ol style="list-style-type: none"> <li>Completion of the RCADS.</li> <li>Completion of the CPC.</li> </ol> </td> </tr> </table>	Parent	Child	<ol style="list-style-type: none"> <li>Neutral question: « Could you recall a typical/classical day of your child? » (audio recording).</li> <li>Questionnaires completion: STAI, BDI PCL.</li> <li>The traumatic event question: « Could you recall what happened to your child? » (audio recording).</li> <li>Subjective stress evaluation following the recall of the traumatic event: was the telling stressful to you? From a scale from 1 being not stressful at all, to 7 being very stressful, could you tell me how stressful it was for you? »</li> <li>Questionnaires completion: PSI, PSOC.</li> <li>Positive question: 'Could you tell me a positive event of your life?' (audio recording).</li> </ol>	<ol style="list-style-type: none"> <li>Completion of the RCADS.</li> <li>Completion of the CPC.</li> </ol>
Parent	Child				
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Phase B : Treatment	Weekly appointment for either CBT or EMDR sessions (1 hour) over a period of 3 months.				
Phase C: Post-treatment assessments	<ol style="list-style-type: none"> <li>Completion of the RCADS.</li> <li>Completion of the CPC.</li> </ol>				

BDI, Beck Depression Inventory; CBT, cognitive behavioural therapy ; CPC, Child PTSD Checklist; EMDR, eye movement desensitisation and reprocessing; PCL, PTSD Checklist; PCOS, Parental Sense of Competence Scale; PSI, Parental Stress Inventory; PTSD, post-traumatic stress disorder; RCADS, Revised Child Anxiety and Depression Scale; STAI, State-Trait Anxiety Inventory.

Finally, functional impairment is assessed with the last six questions and is considered positive if the score is greater than 4. The CPC is a scale meant for school-aged children aged from 7 to 18 years old.

RCADS French version<sup>52 53</sup>: The Revised Child Anxiety and Depression Scale (RCADS) is a 47-item, youth self-report questionnaire with subscales including: separation anxiety disorder, social phobia, generalised anxiety disorder, panic disorder, obsessive-compulsive disorder and low mood (major depressive disorder). It also yields a Total Anxiety Scale (sum of the five anxiety subscales) and a Total Internalising Scale (sum of all six subscales). The RCADS is for children aged from 8 to 18 years.

PTSD Checklist (PCL-5)<sup>50 56</sup>: This questionnaire assesses adult PTSD symptoms during the 7 days preceding the assessment. It consists of 20 questions assessing the four core symptoms of PTSD. For each question, scores range from 0 (strongly disagree) to 4 (extremely agree). The cut-off score is 31.

PSI-SF (Parenting Stress Index-Short Form;<sup>26</sup>): The scale measures the extent of parental stress, as well as the degree of parent-child relationship stress. The time span for the answers to this test is not specified and participants are expected to answer according to their general state. Parental stress is defined as a state of psychological discomfort related to the specific area of child rearing. The questionnaire items are grouped into three domains:

parental distress, child distress and parent/child interaction functioning. To answer, a Likert scale ranging from 1 ('strongly agree') to 5 ('strongly disagree') is proposed for each item. Completing the questionnaire takes 15–30 min.

BDI (Beck Depression Inventory<sup>49 57</sup>): The instrument provides a quantitative measure of the intensity of depressive feelings. The participants are expected to answer according to their current state during the assessment. It usually comprises 21 symptom and attitude items; the short version of 13 items is used for this study. The scale measures a specific behavioural expression of depression, graduated from 0 to 3 by a series of four statements reflecting the severity of the symptom.

PSOC (The Parenting Sense of Competence Scale)<sup>45</sup> is a widely used tool. It comprises 17 items and assesses perceived abilities to manage the demands of parenthood for both mothers and fathers. The time span for the answers to this test is not specified. The PSOC measures parents' perceived parenting abilities with two subscales: skill/knowledge and valuing/comfort.

STAI: This questionnaire, developed by Spielberger *et al.*<sup>58</sup> assesses anxiety as a personality trait (anxiety trait: 20 questions) and anxiety as an emotional state (anxiety state: 20 questions). Patients are given a choice of four responses (1: 'never' through 4: 'almost always'). Scores range from 20 (low anxiety subject) to 80 (very

high anxiety). For the STAI-state subitems, participants are expected to answer according to their current state during the evaluation and for the STAI-Trait according to their general state.

### Audio feature extraction

Parent's will be asked to recall the traumatic event of their child. This speech response will be recorded to extract markers potentially associated with stress levels. Only speech signals from the audio samples will be processed to extract audio features in this study.

Current speech processing—in a non-clinical context—extracts hundreds to thousands of features from a single audio recording. Due to the small-size and high variability of clinical data sets, all possible speech features should not be calculated as we lack statistical power to determine the validity of all features. For this reason, the extended Geneva Minimalistic Acoustic Parameter set (eGeMAPS) will be used to extract acoustic features. eGeMAPS is a predetermined set of 88 features containing the 4 relevant speech features categories mentioned previously; prosodic, formant, source and temporal.<sup>44</sup> This feature set is widely used in processing emotional speech, including stress.<sup>59 60</sup>

### Data security

The recorded narratives will be stored on an external hard drive, which will then be placed in a secured storage room in the department's research archive. The participant files containing all the questionnaires completed by the patient will also be stored in this storage facility. The database created for this study will be stored on the secure server of the Lenzval hospital with restricted access to the people working on this study.

### Data analysis

The calculation of the number of subjects was performed by taking into account the variation in CPC score before and after therapy. A risk alpha of 0.05 was used with a statistical power of 90%. Based on previous studies, children with PTSD before therapy had an average CPC score of 40. To demonstrate a significant difference, the calculation of the number of subjects indicates a number of seven per group. Considering the secondary objectives of the study and the risk of experimental loss, we decided to increase the number of subjects included to 30 per group.

To extract acoustic features from the speech recordings, the programming language Python V.3.7 will be used. One feature of this programming language is a pre-implemented library called PyOpenSmile. This library will be used to extract the 88 acoustic features described by the eGeMAPS feature set for recognising emotional speech. After the features are extracted, statistical methods are applied to the extracted features to determine clinical relevance. In this case, summary statistics such as mean and SD will be used to determine population ranges for the speech features. Other statistical methods of population visualisation will be used to determine patterns

that arise, such as boxplots. Linear mixed effects models and differential statistics, such as significance testing corrected for multiple testing, will be used to determine the validity of speech features for the proposed hypotheses. Correlation analysis will also be performed between speech features (prosody, temporal, formant and source features) and clinical scales. See reference<sup>33</sup> for an overview and explanation of extracted speech features.

Regarding clinical scales, repeated measures analysis of variance will be performed according to parental stress (low level vs high level), times (assessment vs final assessment) and PTSD (CPC cut-off score) or anxiety (RCADS cut-off score) in children. Same analysis will be performed according to parental symptoms of depression and PTSD (low symptoms vs high symptoms). Finally, correlations will be performed between clinical scales of parents and children according to time of assessment. Correlations between the date of the trauma and the variables tested in the child will be also performed before and after the therapy.

### Outcomes

We hypothesise that parental stress may affect the beneficial outcomes of therapy. If our hypotheses were confirmed, this would support the need to consider parental well-being in the treatment of child PTSD. Extracting stress markers from an audio recording of the patient's speech is a low-cost, scalable solution for collecting data and remote monitoring. In addition, it can provide clinicians with objective and sensitive information for diagnosis and evaluating symptoms' severity.

Detecting parental stress from the first consultations and even when scheduling appointments over the phone would allow in the future referring the parents to the appropriate care services and thus, improving the treatment outcome of their children.

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**Data availability statement** This paper is a description of a protocol and no data will be included in the scope of the article.

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