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Development and pilot-testing of an app to complement trauma-focused cognitive behavioral therapy for adolescents

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ABSTRACT

Background: Apps have the potential to support psychological treatments by providing psychoeducation, increasing homework compliance, and generalizing therapeutic skills outside of sessions. However, there are few apps developed to support specific evidence-based treatment for PTSD for adolescents.

Objective: This paper shares experiences developing an app to complement Trauma-Focused Cognitive Behavioral Therapy (TF-CBT). It also describes adolescents' and therapists' perceived usefulness and the potential effect of the app 'My everyday life' on posttraumatic stress symptoms (PTSS).

Methods: We did a needs assessment with adolescents, therapists, and TF-CBT trainers, followed by programming and beta-testing. We carried out a mixed methods study of 59 adolescent patients (aged 13–18 years) and their therapists. Using a triangulation design, we combined quantitative data on app use and changes in PTSS with qualitative data from interviews with 10 adolescents and 10 therapists who described their experiences with the app.

Results: The app includes psychoeducation, mental health self-monitoring, coping tools, and goal-setting functionality. The most used features were psychoeducation and breathing exercises. Few therapists actively used the monitoring progress feature. Both adolescents and therapists found the app beneficial for everyday use, though some therapists were unsure about how to integrate it with TF-CBT. Adolescents reported significant PTSS improvement during TF-CBT with the app as a complement. Adolescents with post-treatment data ($n = 13$) did not report significantly different PTSD improvement compared to adolescents without access to app, but the study lacked power to draw strong conclusions.

Conclusions: The app 'My everyday life' can be useful for adolescents receiving TF-CBT. The therapists may benefit from clearer guidelines on how to integrate apps with evidence-based treatments. Digital tools are a promising avenue for supporting the implementation of evidence-based treatment.

Desarrollo y prueba piloto de una App (aplicación) para complementar la terapia cognitivo-conductual focalizada en trauma para adolescentes

Antecedentes: Las Apps tienen el potencial de apoyar los tratamientos psicológicos al proporcionar psicoeducación, aumentar el cumplimiento de tareas y generalizar habilidades terapéuticas fuera de las sesiones. Sin embargo, existen pocas Apps desarrolladas para apoyar el tratamiento específico para TEPT en adolescentes, basadas en la evidencia.

Objetivo: Este artículo comparte experiencias en el desarrollo de una App para complementar la Terapia Cognitivo-Conductual Focalizada en Trauma (TCC-FT). También describe la utilidad percibida por adolescentes y terapeutas, así como el posible efecto de la App "My everyday life" en los síntomas de estrés posttraumático (SEPT).

Métodos: Se realizó una evaluación de necesidades con adolescentes, terapeutas y formadores en TCC-FT, seguido de programación y prueba beta. Realizamos un estudio de métodos mixtos con 59 pacientes adolescentes (13 a 18 años) y sus terapeutas. Mediante un diseño de triangulación, combinamos datos cuantitativos sobre el uso de la App y cambios en SEPT con datos cualitativos de entrevistas con 10 adolescentes y 10 terapeutas que describieron sus experiencias con la App.

Resultados: La App incluye psicoeducación, automonitoreo de la salud mental, herramientas de afrontamiento y una funcionalidad para establecer objetivos. Las características más utilizadas fueron la psicoeducación y los ejercicios de respiración. Pocos terapeutas utilizaron activamente la función de monitorización de progreso. Tanto los adolescentes como los terapeutas encontraron la App beneficiosa para el uso diario, aunque algunos terapeutas no estaban seguros de cómo integrarla con la TCC-FT. Los adolescentes reportaron una mejoría significativa en SEPT durante la TCC-FT con la App como complemento. Los adolescentes con

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PALABRAS CLAVE

Salud móvil; terapia; tecnología; salud digital; tratamiento basado en la evidencia

HIGHLIGHTS

- We developed an app to complement Trauma-Focused Cognitive Behavioral Therapy for adolescents.
- Adolescents and their therapists experienced that the app supported the adolescents' coping with stress in daily life.
- Guidelines for how to use apps together with evidence-based treatment may be needed.

datos posteriores al tratamiento ($n = 13$) no reportaron una mejoría significativamente diferente del TEPT en comparación con los adolescentes sin acceso a la App, pero el estudio carecía de la potencia suficiente para obtener conclusiones sólidas.

Conclusiones: La App “My everyday life” puede ser útil para adolescentes que reciben TCC-FT. Los terapeutas podrían beneficiarse de directrices más claras sobre cómo integrar las Apps con tratamientos basados en la evidencia. Las herramientas digitales son una vía prometedora para apoyar la implementación de tratamientos basados en la evidencia.

1. Introduction

The treatment of posttraumatic stress disorder (PTSD) in adolescents (defined here as 13–18 years old) can be challenging. PTSD involves persistent trauma reminders, heightened sense of fear, and negative thoughts and feelings (American Psychiatric Association, 2013), which affects daily life outside the therapy room when the therapist is typically unavailable. Additionally, avoidance may deter the use of skills learned in therapy (Dobson & Dobson, 2018) and there can be numerous barriers to completing therapeutic homework (Bunnell et al., 2021). Challenges such as these can possibly be mitigated by using a mobile app alongside treatment.

Mobile phones are portable and convenient to use in many situations. For example, they provide individuals with access to tools to use directly in triggering situations or times of significant distress (Lui et al., 2017). Mobile apps may help with psychoeducation by providing means of reading information at home, increasing homework compliance, and generalizing therapeutic skills outside of sessions (Bunnell et al., 2021; Lui et al., 2017; Olff, 2015). Indeed, studies have found that receiving app-based stress intervention stress can reduce mental distress in students (Harrer et al., 2021). Apps can also encourage adolescents to take ownership of their therapeutic process and provide opportunities for self-reflection and rehearsal of skills (Gindidis et al., 2019). Furthermore, apps can be used for assessment, treatment planning, tracking of treatment fidelity and treatment outcome (Pacheco & Scheeringa, 2022). They can also help implement evidence-based treatments by enhancing delivery of interventions and extend the care outside treatment sessions (Erhardt et al., 2022). These attributes could potentially contribute to improved clinical results.

Several reviews have investigated the effects of mental health apps used as standalone interventions, both in adults (Linardon et al., 2019; Sander et al., 2020; Wang et al., 2020) and adolescents (Domhardt et al., 2021). In general, systematic reviews conclude that there are few apps targeting PTSD that can be considered evidence-based with the exception of the ‘PTSD Coach’ (Wang et al., 2020), originally developed for veterans and designed to help individuals with PTSS to better understand and self-manage their symptoms (Bröcker et al., 2023; Kuhn et al., 2018). The main

features of this app are that it provides reliable information on PTSD and treatments that are efficient, tools for screening and tracking symptoms, convenient, easy-to-use tools to handle stress symptoms and direct links to support and help. This app has shown good effect as a standalone intervention as compared to a waiting list (e.g. Hensler et al., 2022: difference in self-reported PTSD symptoms after 3 months $d = 0.45$), whereas it did not add any further effect when used as a complement to treatment (Possemato et al., 2023: difference in clinician-rated PTSD symptoms posttreatment $d = .01$). To our knowledge, this app is not developed for or tested with adolescents or tested together with evidence-based treatments. There are apps to support adolescents with depression and anxiety (Bevan Jones et al., 2023), and several standalone apps contain different skills training features that can support traumatized youth, such as relaxation exercises. However, there are no current apps that are specifically made to support adolescents with trauma experiences and PTSD and no apps that are developed to support the use of TF-CBT.

Trauma-focused cognitive behavioral therapy (TF-CBT) is recommended as the first choice of evidence-based treatment for children and adolescents with PTSD (ISTSS, 2019; NICE, 2018). An app that can support this treatment could therefore be highly valuable. TF-CBT (Cohen et al., 2017) is a short-term (between 8 and 16 sessions over a period of 2–4 months), phase-based, trauma-focused treatment model that includes the following components: psychoeducation, coping with stress, affect regulation, cognitive coping, trauma narrative work, cognitive restructuring, *in vivo* exposure, and safety planning for the future. TF-CBT also includes a caregiver component, aiming to strengthen caregiver skills and enhance parental support of the traumatized child. TF-CBT prescribes learning strategies for coping with trauma reactions, which may be challenging for adolescents to implement on their own between sessions. Integrating an app with TF-CBT for adolescents could help enhance accessibility to tools and support between sessions, self-monitoring, and engagement in treatment. TF-CBT prescribes learning strategies for coping with trauma reactions, which may be challenging for adolescents to implement on their own outside the therapy context. Integrating an app with TF-CBT for adolescents could help

enhance accessibility to tools and support between sessions, remind them of doing helpful exercises, possibilities to self-monitor improvement, and increase engagement in treatment. Still there are no current apps that specifically targets trauma reactions and needs that adolescents may have while undergoing TF-CBT.

This paper describes the process of developing an app to be used as a complement to TF-CBT together with users (i.e. adolescent patients and therapists) and app programmers, as well as the pilot testing of the use of the app together with TF-CBT. Our research questions were: (1) What functions should an app to support TF-CBT have, and how should it be designed? (2) In what ways can this app be helpful, according to users? (3) To what extent are PTSS reduced during TF-CBT with access to this app?

2. Methods

2.1. Study context

The app was developed at the Norwegian Center for Violence and Traumatic Stress Studies (NKVTS), in collaboration with the University of Oslo's services for developing mobile apps for research. NKVTS has supported the implementation of TF-CBT in regular generalist outpatient child and adolescent mental health services (CAMHS) nationwide in Norway for approximately 10 years. The project was funded by the Dam Foundation through The Norwegian Council for Mental Health (grant number 2019/HE1-256689) and NKVTS. In Phase 1, which focused on addressing research question 1, our team concentrated on app development. This phase encompassed a needs assessment, programming, and beta-testing of the application. Moving into Phase 2, which targeted research questions 2 and 3, we shifted to pilot testing the app. For research question 2, we employed qualitative methods, whereas research question 3 was approached with quantitative methods.

2.2. Phase 1 – app development: needs assessment, programming, and beta-testing of the app

The target group for the app was 13–18-year-old adolescent patients with trauma exposure and clinical levels of PTSS. We interviewed experienced certified TF-CBT trainers ($n = 3$), TF-CBT therapists ($n = 3$) and patients who had received TF-CBT ($n = 3$). As we have an on-going collaboration with CAMHS for implementation of TF-CBT, trainers at NKVTS approached several CAMHS and invited interested therapists to provide us with input for an app to be used with TF-CBT. Some of these also asked previous adolescent patients if they were interested in provided

their input. If they agreed, we contacted them. No personal information on these participants were collected.

The number of interviewees were chosen to secure some variability at the same time as being feasible to recruit and interview within the available time and resources. We used convenience sampling to recruit participants. The interviews lasted for 30–60 min. Questions were based on 10 years of experience with implementation of TF-CBT in CAMHS. Questions we asked both adolescents and TF-CBT trainers/therapist were: What functions should an app to be used to support TF-CBT have? What are the relevant questions to ask in a routine outcome monitoring feature? Are there other app functions that might be helpful during TF-CBT? How should the app look? The TF-CBT trainers and therapists were also asked about what their experiences with other apps in treatment with adolescents, how they implemented these, and their thoughts on how aid implementation of this app in treatment. TF-CBT trainers and therapists were interviewed during their working hours and were not reimbursed. Adolescents were awarded with gift cards for participation equivalent to \$30.

Based on the interviews and the TF-CBT manual, we made paper drawings of the app structure and content and wrote the texts and recorded the audio files. We established a collaboration with a team specialized in developing user interface and programming mobile apps for research at the University of Oslo. This team provided screenshot drafts of the app. We printed these as small individual cards and made sure that the internal logic and content was per our requirements. We gave feedback to user interface experts, and the drafts were improved iteratively. We then consulted three adolescents from our network of colleagues, who were not referred to treatment, to check for understandability and user-friendliness. Next, the programmers coded the app. When we had a useable version of the app, we consulted the TF-CBT expert trainers again and used their feedback to improve the app.

2.3. Phase 2: pilot-testing in regular TF-CBT treatment

We pilot-tested the app in regular TF-CBT treatment with 59 adolescents and their therapists to assess the acceptability and perceived usefulness of the app. Further, we collected pre–post data on mental health, use of the app, and interviewed adolescent patients and therapist feedback on perceived benefits and concerns. The design of this pilot study was a combination of a prospective pre/post study, diary study and qualitative study.

2.3.1. Participants

As part of a large nationwide implementation project financed by the Norwegian Health Directorate therapists at three-quarters of the CAMHS (clinics $n = 65$)

in Norway had received training in TF-CBT when the app development project started (see Skar et al., 2022 for more details about the larger project). Due to resource limitations, we could not invite all 65 clinics to take part in the current project. Therefore, based on convenience sampling, 17 clinics were asked to participate, of whom 11 agreed to take part as pilot clinics for this project. We also recruited via a Facebook page for TF-CBT in Norway and via the TF-CBT training courses, which added 6 more clinics (17 in total). All therapists working with TF-CBT at the participating clinics, both certified therapists and those under training, were invited to take part in the study. Therapists were informed about the study and trained in the use of the smartphone app as a supplement in the TF-CBT treatment.

The therapists were asked to invite all their patients who met the specified inclusion criteria: age 13–18 years, trauma exposure and clinically significant symptoms of PTSD, as well as were offered and had agreed to receive TF-CBT. Therapists recruited participants to pilot test the app during TF-CBT from September 2020 until April 2022. For this pilot study, the sample size was constrained by available resources, specifically the number of participants we could recruit within the grant period. While this limitation restricts the use of inferential statistics to analyze effects, our primary goal was to gather preliminary information on other aspects of the intervention. Therefore, we considered the sample size adequate for our purposes (see Lakens, 2022).

2.3.2. Comparison sample

For comparison of treatment results of TF-CBT with and without access to TF-CBT, we used data from a previously collected but similar sample from the national implementation of TF-CBT in Norway collected between 2018 and 2020 (i.e. before developing the app), where all newly referred children and adolescents in 23 Norwegian CAHMS were screened for posttraumatic stress symptoms. Those with elevated scores were offered TF-CBT (see Jensen et al., 2022 for details of the sample). Of the 173 patients who participated in the study, 99 patients were between 13 and 18 of age and received TF-CBT with confirmed fidelity according to a modified version of the TF-CBT Brief Practice Fidelity Checklist (Deblinger et al., 2014) and were used as the comparison sample.

2.3.3. Measures

PTSD was assessed in the app at pre – and post-treatment with the Child and Adolescent Trauma Screen, version 2; CATS-2 (Sachser et al., 2022). Cronbach's alpha for DSM-5 PTSD was .93. The daily questionnaire in the app included questions about PTSS, stress and social support, for example 'During this day: have upsetting thoughts or memories of what happened

popped into your head?'. In addition, we also asked one question measuring self-reported app usage: 'What parts of the app did you use today?' with a list of the functions of the app as the response categories. Details about the daily questionnaires can be found in the codebook (Birkeland et al., 2021).

Fidelity to TF-CBT was measured by the modified version of the TF-CBT Brief Practice Fidelity Checklist (Deblinger et al., 2014). Certified TF-CBT therapists scored their own fidelity. For TF-CBT therapists in training, TF-CBT trainers scored fidelity based on audio recordings of treatment sessions. This was registered in a separate quality monitoring system for therapists, and the data sources were linked to each other in a data file. As this is a pilot study, we have little prior information on how the app can best be used, and fidelity to app use was not measured.

2.3.4. Procedure

The design of this study included several data collections: pre/post treatment surveys, diary data, and qualitative interviews. The adolescents were asked to respond to surveys pre- and post-treatment on their phones the day that they downloaded the app (at the beginning of therapy) and after the final TF-CBT session. The diary data collection period lasted for the duration of the treatment. We used a fixed sampling scheme: each evening, participants received a notification two hours before their self-reported bedtime that a questionnaire containing 25–28 items (mean response duration = 1.5 minutes) was available for completion. The bedtimes for each day were set by the adolescents when downloading the app. All diary questions referred to experiences of the current day. Data were stored on their smartphones (password protected) and sent to a secure research server (Services for Sensitive Data at the University of Oslo).

The app showed graphs of overall symptoms, each symptom, and positive and negative emotions (see Figure 1), as well as personalized advice on tools to try (based on high symptom levels). To further increase motivation, we embedded several gamification elements both for compliance to the daily registration of symptoms (e.g. they got to know their response rate/number of assessments), but also for completing their own goals (e.g. receiving stars and colorful confetti for accomplishments).

The therapists attended a 1–2 hour digital training session on the content of the app and suggestions on how this could be used during each of the phases of TF-CBT, as well as the design of the research project and how to recruit participants. They were also provided with written materials on the content of the app as well as the recruitment procedure and were asked to download the app and try it for themselves before introducing it to participants. The adolescents were not required to use the app to receive TF-CBT.

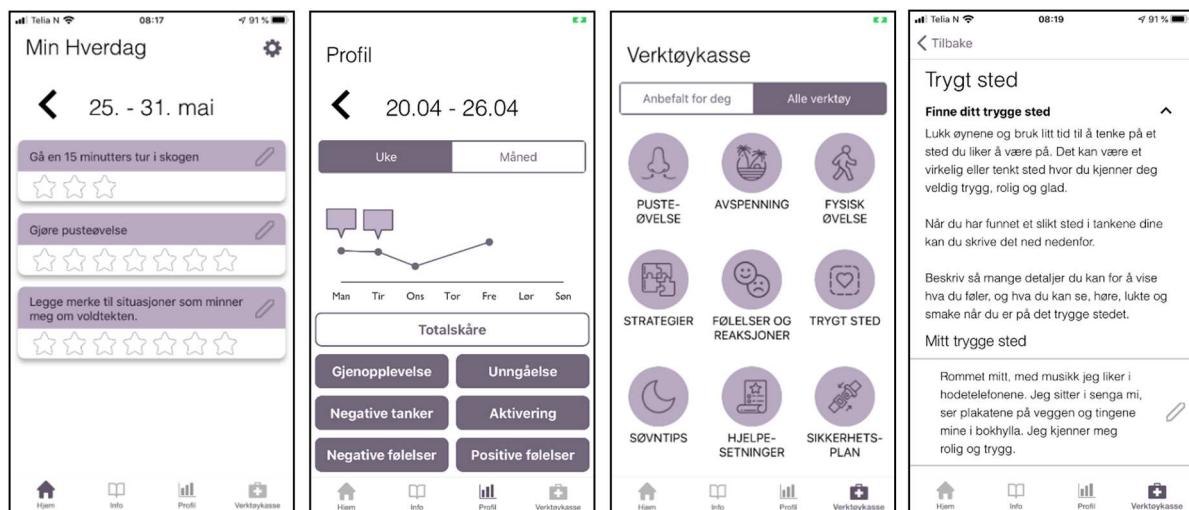


Figure 1. Screenshots from the app 'My everyday life' (in Norwegian).

However, they voluntarily agreed to explore the app at their own pace and discretion as part of their treatment.

The participants were compensated with gift cards. The first 10 adolescents received a reward of approximately \$50 for participating, and an additional \$50 for completing at least 80% of the daily assessments. After feedback from therapists and adolescents that the reward scheme was too slow, we changed the reward schedule so that the remaining participants received \$20 for participating and then \$20 for completing 20 daily assessments until a maximum of \$100 was reached for 80 daily assessments. Participants who were interviewed received \$30.

2.3.5. Quantitative analysis of use and change

We used descriptive analysis to assess the use of the app. We used mixed effects analysis with random effects to assess change in PTSS from before to after treatment, as well as to compare change with our comparison sample. To study whether the effect of time was different across sample type (study sample with access to the app vs comparison sample without access to the app), we added an interaction term in the mixed effects analysis.

2.3.6. Qualitative interviews and analyses

To achieve a greater understanding of how the app was used in practice, we interviewed adolescents and therapists who had tested the app in regular TF-CBT treatment. We made an a priori decision to interview 10 adolescent patients and 10 therapists. We considered that this would provide us with a reasonably large pool of experiences to learn from, but still be within the time and resource limits of this pilot study. We consecutively invited adolescents who had been introduced to the app at least six months earlier, as well as replied to at least 10 daily questionnaires, until we had recruited 10 adolescents for interviews.

To obtain interviews with 10 adolescents, we needed to reach out to 16 adolescents. To obtain interviews with 10 therapists, we asked 11 therapists.

We used semi-structured qualitative interviews conducted over the phone or video call to collect information on perceived usefulness of the app. Topics covered were experiences with the information parts of the app, tools and exercises, progress monitoring and use of app during treatment. The topics started with open questions before asking more specific questions about the experiences with the app's features. Examples of questions we included are: What is your overall impression of this app, and how was it like to use the app? What tools did you use? How did you find that the tools and exercises worked for your patient? How did you introduce the app in the first session, and how did you use it in the subsequent sessions? What did you find useful, and what was less useful? Did the graphs in the app provide you with any additional information that you wouldn't have otherwise obtained? The interviews lasted from 20 minutes to 1.5 hours and were recorded in a secure app that encrypts data before sending them to a secure research server. The interviews underwent verbatim transcription and were analyzed using Nvivo (Lumivero, 2017).

We used inductive content analysis (Vears & Gillam, 2022) to analyze the transcripts of interviews. This is a method well-suited for qualitative health research, where the interview questions are likely to be quite specific and direct to elicit descriptions of experiences (Vears & Gillam, 2022). Two raters (C. B. and M. S. B.) first familiarized themselves with the data. Next, the data was coded independently by the two raters, highlighting relevant and interesting content in general categories. Then the two raters independently developed one set of subcategories for adolescent interviews, and one set of subcategories for therapist interviews. The raters then reconciled differences by explaining their

views and discussed until consensus was reached. Subsequently, all co-authors were presented with the proposed results and supporting data for a credibility review. Given their extensive knowledge of TF-CBT and its implementation, they provided feedback and suggested minor adjustments. Finally, both raters refined the subcategories by going back to their original codes and making sure that the content of the interviews was well represented in the final set of categories.

2.3.7. Ethical considerations

The pilot study was approved by the Regional Committee for Medical and Health Research Ethics (reference 2019/1235). An approved Data Protection Impact Assessment (DPIA) was developed in collaboration with the Norwegian Centre for Research Data (reference 680226). In addition, several of the Norwegian CAMHS conducted their own ethical assessments based on these documents. The data that support the findings of this study are available on request from the corresponding author, M. S. B. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

The therapists informed potential participants about the study and collected written informed consent to participate from the participants and, if they were between 13 and 15 years of age, also from both parents. There were two exceptions from collecting consent from both parents: When the child welfare had the responsibility for the participant, they consented on the participant's behalf. When the therapists had reason to believe that the participant was exposed to violence in close relations, participants from 13 years of age could consent on their own behalf.

3. Results

3.1. Phase 1: needs assessment, programming and beta-testing of the app

The needs assessment interviews with patients and therapists resulted in the following suggestions for content of the app: psychoeducation, more than one audiotaped breathing exercise with subtexts, provide opportunities for tracking development and writing comments, possibilities for personalization, and reminders to do treatment-relevant tasks. Regarding the design, they emphasized the importance of a user-friendly, easily understandable, gender neutral and non-childish appearance. We also looked through the content of components of TF-CBT to see which of them that could be supported by app content. We found that the components psychoeducation, coping with stress and affect regulation, cognitive coping, and safety planning for the future were well suited to be supported by an app.

Some of the suggestions from adolescents, therapists, and TF-CBT trainers were not possible to fulfil for financial or ethical/data protection reasons. For example, we were unable to develop a computer game, integrate functions for capturing photos or recordings of therapy sessions, or enable the sharing of patient-provided information from the app with therapists. We also had to postpone the development of functions to support the cognitive coping component for financial reasons. Gradual exposure to trauma memories is a crucial component of TF-CBT. However, we decided against creating features encouraging adolescents to do exposure on their own (both the gradual exposure, trauma narrative work and *in vivo* exposure). This was because we planned to make this app openly accessible, and unguided exposure without a treatment plan might increase symptom severity (Cuijpers & Schuurmans, 2007). Thus, we created a specification of requirements of the app based on the content of TF-CBT, research about other similar apps such as the PTSD Coach, the input from users, as well as technical/financial limitations, which we gave to the programmers. The app was thus designed to target three main aims:

- Provide tools for rehearsal of valuable skills in line with TF-CBT. Adolescents receive tools that they can use for rehearsal and use in their everyday life. By monitoring daily mental health, the app suggests specific tools based on the adolescents' most severe symptoms.
- Allow for opportunities for self-reflection. Adolescents can track their changes in symptoms and positive feelings throughout treatment and receive timely information on their progress.
- Encourage adolescents' ownership of their treatment. Adolescents can customize strategies and goals based on their own individual needs and preferences.

Thus, the app 'My everyday life' (in Norwegian: 'Min hverdag') has the following functions: psychoeducation about trauma, PTSD and sleep; mental health self-monitoring illustrated in graphs; a toolbox (e.g. relaxation exercises, personalized strategies, safe place, helpful cognitions); and goal setting functionality (see Figure 1). Table 1 shows which components of TF-CBT that were addressed in the app.

3.2. Phase 2: pilot-testing in regular TF-CBT treatment

3.2.1. Sample characteristics

During the period of September 2020 to March 2022, we recruited and trained 59 therapists from the 17 included CAMHS in the use of the app. During the same period, they recruited 59 adolescents (0–3

Table 1. Features of the app and components of treatment.

Components of treatment	Features of app
<i>TF-CBT: Stabilization and skill-building</i>	
Psychoeducation	Information about trauma, PTSD, sleep
Parenting	Not targeted specifically
Relaxation skills	Breathing exercise, progressive relaxation, grounding exercise (audio). Creating/reviewing personal description of safe place. Creating/reviewing personal list of strategies.
Affective Modulation skills	Emotions and reactions (audio)
Cognitive coping skills	Not targeted specifically
<i>TF-CBT: Trauma narrative and processing</i>	
Trauma narrative and cognitive processing	Creating/reviewing personal helpful cognitions.
<i>TF-CBT: Integration and consolidation</i>	
<i>In vivo</i> mastery of trauma reminders	Not targeted specifically
Conjoint youth-caregiver sessions	Not targeted specifically
Enhancing safety	Creating/reviewing personal safety plan. List of help lines to get further support. Identifying personal contact person.
<i>General components</i>	
Self-monitoring symptoms	Daily questions of symptoms with reminders
Homework/personal goal setting	Personal goal setting (gamified, with reminders) The features above can be used during and between sessions.

adolescents per therapist). Among the recruited adolescents, 26 adolescents completed TF-CBT whereas 3 did not start as planned and 16 discontinued TF-CBT (Figure 2). Among those 16, 8 discontinued TF-CBT for reasons that were unrelated to the TF-CBT (e.g. other illness), four dropped out from treatment all together, and reasons could not be ascertained in 4 cases. For 14 adolescents, we did not obtain information of treatment completion or not from the therapists. Information about the 56 adolescents who started TF-CBT is shown in Table 2.

3.2.2. Quantitative results of app use

The app was introduced to adolescents in the first phase of TF-CBT. The mean number of days

TF-CBT lasted after introduction of the app in treatment was 140 days (range 32–347). The mean number of daily questionnaires the adolescents answered was 53.1 (range 1–165) and the mean percentage of daily responses was 42.7% (range 4.3–100). Some adolescents also continued to use the app after TF-CBT was completed ($n = 6$).

Table 3 shows what parts of the app the 26 adolescents who completed TF-CBT reported that they had used during the day. There were large variations: while some features were used by a majority of adolescents, other features were rarely used.

3.2.3. Qualitative data on app use

To understand more about how the adolescents and therapists experienced using the app, we conducted a content analysis of qualitative interviews. The adolescents who participated in these interviews were not significantly different from those who did not with regards to gender, age, number of trauma types, or symptoms of PTSD at baseline (p -values between .407 and .931). We were especially interested in why some features were used much and others not, and how the app was integrated with TF-CBT as well as with everyday life. We decided to organise the results in the same categories for both adolescents and therapists. The inductive content analysis resulted in four categories related to both adolescents’ and therapists’ experiences of app use together with TF-CBT. The categories are: (1) Perceived usefulness of app elements, (2) monitoring the development of symptoms, (3) integration with TF-CBT, and (4) integration with everyday life.

(1) Usefulness of app elements

The adolescents experienced some features of the app more useful than others. Among these were psychoeducation, breathing exercises, safe space, and

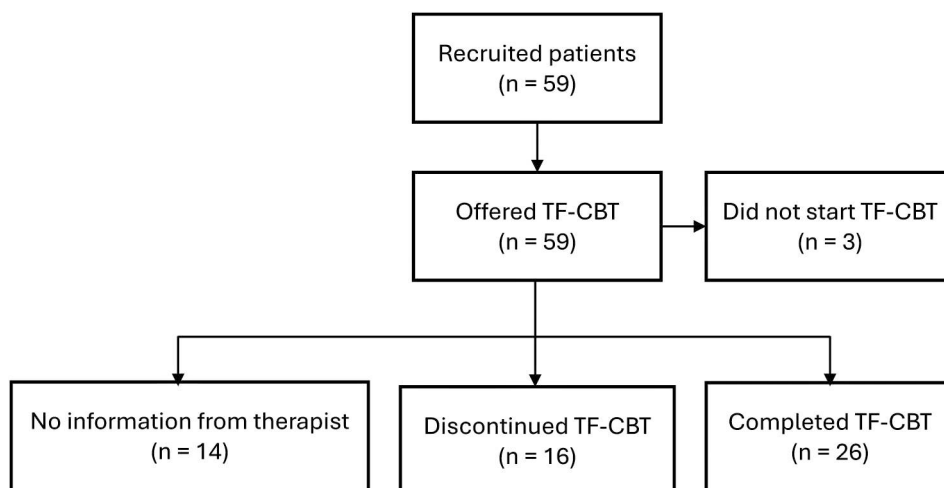


Figure 2. Flowchart of participants in the pilot study.

strategies for coping with stress. The adolescents liked the information parts with psychoeducation about trauma, PTSD, and sleep. They stressed that this information was easy to understand, relevant, and contained the appropriate information. One adolescent stated that this helped them understand themselves better:

I have been bullied for many years, and when I read about what trauma is like, I understood better the symptoms I've had, for example that I hardly sleep at night and felt bad about myself. (adolescent 3)

The breathing exercises were mentioned as particularly useful. Adolescents experienced these as easy to follow, and they liked the possibility to choose between several narrating voices. One adolescent said that:

Very relaxing, very pleasant voice, and nice instructions. It was very clear to me what to do. (adolescent 7)

The therapists also liked the psychoeducation, breathing exercises, suggested techniques for coping with stress such as the safe place exercise, and the goal setting feature. One therapist said they used the safe place exercise the same way they would do it without the app, except that the patients wrote down feelings, sounds, and smells connected to the safe space in the app. They further explained that writing this in the app made it easily accessible for later use.

One therapist mentioned that having the goal setting feature was useful to keep track of the adolescents' goals:

(...) it was actually quite useful. because when we usually set goals in therapy, it might happen that the goals are forgotten (...) but when [the patient] came in here, I also said let's take a look at the app,

and then maybe we looked at the registrations, and the goals are there, and I thought okay, then I see that we set goals last week that you could go skateboarding a little more. Have you done that? So, it was a good reminder of the goals that had been set. This made it clear what has been accomplished. (therapist 1)

Several of the therapists did not use the app's goal feature. One therapist mentioned that it can be too much for the adolescent to remember the goal setting as well as answering the questionnaire every day.

(2) Monitoring the development of symptoms

The experiences of answering the daily questionnaires varied considerably. Some adolescents were positive or neutral. One described that it became a habit, whereas another explained that it felt useful to answer the questionnaire because it felt like a closure and a way to let go of what had happened that day:

It helps me get some of what happened that day out of my head. So that I don't have to have it with me all the time. (adolescent 3)

Another adolescent appreciated that someone, even if it was only a phone, asked about their day. However, several of the adolescents found answering these questions less appealing. Some mentioned that there were too many questions in the questionnaire and that answering them every day got a bit boring and that the questions were predictable. Some of the adolescents proposed that the number and ordering of questions should vary. There was also a large variation in the use of results from the symptom monitoring. Several adolescents found it useful to look at the graphs. For example, one adolescent said that they used the graph as a review, where they could look at how the

Table 2. Descriptive information of the sample at baseline ($n = 54$)*.

	Total sample ($n = 54$) % (n) / M (SD)	Completed TF-CBT ($n = 24$) % (n) / M (SD)	Discontinued TF-CBT ($n = 16$) % (n) / M (SD)	No info on TF-CBT ($n = 14$) % (n) / M (SD)
Female	85.2 (46)	91.7 (22)	87.5 (14)	71.4 (10)
Age	15.5 (1.5)	15.5 (1.3)	15.3 (1.7)	15.7 (1.8)
Lives with at least one parent	81.5 (44)	83.3 (20)	81.3 (13)	78.6 (11)
Mean number of trauma types	5.5 (2.8)	4.6 (2.6)	6.7 (2.5)	5.6 (3.2)
Natural disaster	3.7 (2)	0 (0)	12.5 (2)	0
Accident	27.8 (15)	20.8 (5)	31.3 (5)	35.7 (5)
Family violence	50.0 (27)	45.8 (11)	18.8 (3)	28.6 (4)
Peer violence	44.4 (24)	33.3 (8)	50.0 (8)	57.1 (8)
Assault	7.4 (4)	8.3 (2)	6.3 (1)	7.1 (1)
Observed family violence	50.0 (27)	33.3 (8)	68.8 (11)	57.1 (8)
Observed peer violence	44.4 (24)	25.0 (6)	68.8 (11)	50.0 (7)
Sexual abuse	57.4 (31)	58.3 (14)	68.8 (11)	42.9 (6)
Sexual abuse online	44.4 (24)	37.5 (9)	56.3 (9)	42.9 (6)
Bullying	57.4 (31)	45.8 (11)	68.8 (11)	64.3 (9)
Cyberbullying	48.1 (26)	41.7 (10)	56.3 (9)	50.0 (7)
Death of relative	51.9 (28)	50.0 (12)	56.3 (9)	50.0 (7)
Medical treatment	11.1 (6)	16.7 (4)	12.5 (2)	0
War	1.9 (1)	0	6.3 (1)	0
DSM-5 PTSD sum score	39.1 (9.9)	39.6 (11.1)	40.5 (6.4)	36.7 (11.5)
Probable DSM-5 PTSD	87.0 (47)	87.5 (21)	81.3 (13)	92.3 (12)
Number of sessions of TF-CBT	missing	15.5 (4.6)	6.8 (4.2)	missing

Note. *Five participants did not provide this information.

Table 3. Adolescents' usage of app features ($n = 25$).

App feature	Used at least once % (n)	Mean number of days used per adolescent Mean (SD)
Breathing exercise, progressive relaxation, grounding exercise (audio)	68.0 (17)	10.7 (24.6)
Homework/personal goal setting	60.0 (15)	16.4 (38.9)
Psychoeducation about sleep (text)	56.0 (14)	1.4 (0.9)
Emotions and reactions (audio)	48.0 (12)	1.2 (1.8)
Creating/reviewing personal list of strategies.	44.0 (11)	6.2 (23.8)
Psychoeducation about trauma and PTSD (text)	36.0 (9)	1.4 (2.6)
Self-monitoring symptoms	32.0 (8)	9.6 (33.8)
Creating/reviewing personal description of safe place	28.0 (7)	0.8 (1.7)
Creating/reviewing personal helpful cognitions.	24.0 (6)	0.4 (0.9)
Creating/reviewing personal safety plan	8.0 (2)	0.2 (0.7)

week had been and how their feelings were, and if they scored high on negative or positive feelings:

Yes, I use it every now and then to see how I've been doing. I may do it at the end of the week to see how my week has been. How my feelings have been, if I have been high on negative emotions. Or positive. (adolescent 3)

Another adolescent expressed that it was motivating to see the graph, especially if they saw that they scored better. This would give them the motivation to continue answering the questionnaire. Other adolescents expressed that they did not feel that looking at the graph was useful. One adolescent mentioned that the report induced feelings of guilt:

It was useful for my therapist. But I don't really know if it was of any use for me. Because I started thinking 'what have I done wrong now that have made the symptoms increase again?' (adolescent 4)

Some therapists found that the graphs gave structure and valuable information to use when starting a therapy session, and used it as an invite to conversations, particularly when the adolescent had provided data. Instead of just asking the adolescent how they had been since last time, they could now talk about more specific issues such as re-experiencing or having negative feelings:

Then I can explore this with them and say, "Aha, are you feeling that way? Do you have a lot of nightmares, and why do you think that is?" (...) Then we can talk about it. This contributes to self-reflection. I think it can contribute – somewhat depending on how I choose to use it – to an increased understanding of the connection between what you do and how you feel. (therapist 9)

Some therapists did not want to look at the symptom development graphs as they thought that it was too private. For example, one therapist felt that the app was the adolescent's personal space, that they did

not feel that they could request the information. One therapist said:

(...) I have to ask very specifically if they want to share, because it's not like they come and want to show me. It's been a bit like that, I've felt a bit that it's their business, and that I, that's maybe why I haven't gone into it like that, I don't know. (...) I don't know if they had been totally honest (if they knew I would look at it). I'm not sure but some might feel it very invasive. (therapist 4)

Another therapist mentioned that all the information the adolescents registered in the app is related to what they are going through in therapy anyway, so the therapist considered it to be natural for the adolescents to share:

I think that what is in that app concerns therapy and what you work with. It is difficult for me to imagine a situation where something comes up that cannot be shared in therapy. (therapist 1)

One therapist described that the adolescent they had in therapy often reported doing better than the monitoring in the app showed:

It was a bit interesting because she often reported that she was doing better than she was (according to the app). We looked at it together, and then I discovered that this was not the case. And it was almost a bit like reading her diary, and then I thought that it was a way for her to start expressing what she is struggling with. ... It becomes so obvious when you see the graph, so it becomes an opportunity to explore the painful things. (therapist 3)

(3) Integration with TF-CBT

Adolescents told us that therapists introduced the app during the first phase of TF-CBT, when the focus is on psychoeducation and skills learning. The adolescents looked through the app together with their therapist and they tested some of the tools together. For example, one adolescent said that they used the breathing exercise together:

We put the phone on the table and then we put it on speaker and then we sat there and listened. (adolescent 2)

Many adolescents reported that the app was not used much after the first few treatment sessions. One adolescent explained that the therapist usually asked about app usage at the start of each therapy session, but the therapist did not use the tools or the monitoring function actively during treatment sessions.

Therapists generally found the tools to be well suited to use with TF-CBT. One therapist stated that:

Those who are really motivated for treatment can do this to reinforce what we are doing in the sessions. I think this resonates with a lot of adolescents and that it's nice that the clinics can provide young people with some digital tools. (therapist 5)

One therapist mentioned it might be useful to familiarize oneself with the app and get experience with how to use it before introducing it to patients. However, several therapists mentioned that they could not find the time to do so beforehand, but also acknowledged that this is a matter of priorities.

One therapist recommended to use some time going through the app with the adolescent and underscored that it is not sufficient to just offer the adolescent to download it and use it on their own. In line with this, another therapist also mentioned listening to the breathing exercises together with the adolescent:

I think it is important to listen through it together and that they carry out the exercise in the office. (therapist 1)

As for other therapists, they did not feel the need to explore the app together with the adolescents, they just let the adolescents use the app on their own.

(4) Integration with everyday life

One of our primary goals was that the app could be integrated in the adolescent's everyday life. Some adolescents described that they used the breathing exercises in various situations: when feeling angry, or when being reminded of their traumatic experiences:

If, for example, I'm sitting around, for example at the shopping centre, and if the trauma wakes up in my head, then it's a good thing to use those breathing exercises, because then I can start talking to myself, and say that it's going perfectly fine. And just start doing breathing exercises. And then my body gradually calms down. (adolescent 6)

One therapist appreciated that having an app with a toolbox including breathing exercises could act as a bridge between the therapy sessions and the adolescent's daily life. They said:

What has been particularly good is that it has been a very useful tool for the patient between sessions. We can practice a number of strategies in the sessions that the patient will then use until the next session, and it has been great to use the app to support this. (...). These audio files, for example, that you could just listen to – and experience that it helps. In a way, it becomes an extended arm from me and a very good tool for the patient between sessions and when needed. (therapist 8)

This therapist also mentioned that the app might function as a safety net, considering that adolescents usually have their phone with them all the time:

I have the impression that it has been useful both because he has been able to use the strategies, but also because the young people have their phones with them all the time. For me it is reassuring to know that he has it available. I think that it has been quite helpful. (therapist 8)

3.2.4. Changes in PTSS

Of the 24 adolescents who completed TF-CBT, and who provided pre-treatment data on PTSS, 13 also provided post-treatment data. The level of PTSS was reduced from $m = 41.6$ at pre-treatment to $m = 25.8$ at post-treatment on the CATS scale, that is scored from 0 to 60 (Figure 3). Linear mixed effects indicated that the uncontrolled pre–post change was statistically significant (est = -15.0 , 95% CI -20.6 to -9.3 , $p < .001$). Prior to treatment, 88% of patients ($n = 21$) met the criteria for probable DSM-5 PTSD. Following treatment, this decreased to 29% ($n = 4$). In the linear mixed effects analyses that combined the treatment completers from the current sample ($n = 13$) with the comparison sample ($n = 99$), no statistically significant group \times time interaction effect was found (est = 2.6 , 95% CI -3.4 – 8.5 , $p = .394$). However, as the sample size for the smallest group in this analysis was quite low, the analyses were underpowered, and it was not possible to make strong conclusions about differences in effect.

4. Discussion

In this paper, we set out to answer the following research questions: (1) What functions should an app to support TF-CBT have, and how should it be designed? (2) In what ways can this app be helpful, according to users? (3) To what extent are PTSS reduced during TF-CBT when supported by this app?

To determine the functions of this app, we integrated components of Trauma-Focused Cognitive Behavioral Therapy (TF-CBT) with the features requested by adolescents and therapists we interviewed, all within our ethical and financial constraints. Our needs assessment revealed that adolescents and therapists sought tools to rehearse TF-CBT skills, methods to monitor treatment progress, and ways to encourage adolescents to take responsibility for their treatment.

While many existing apps offer tools for learning relaxation and other transdiagnostic skills, and psychoeducational information about trauma and PTSD is available on the Internet, our app stands out by providing content specifically written for adolescents. This content is quality-checked by trauma treatment experts and includes several useful features conveniently assembled in one place. To further support TF-CBT implementation, the app could integrate additional functions for more comprehensive treatment. Recent research has explored apps with cognitive restructuring features (Erhardt et al., 2022) and exposure elements (Miller et al., 2022), suggesting that future versions of TF-CBT apps could include similar features.

Few current apps offer methods to monitor PTSD symptom reduction alongside treatment. Although

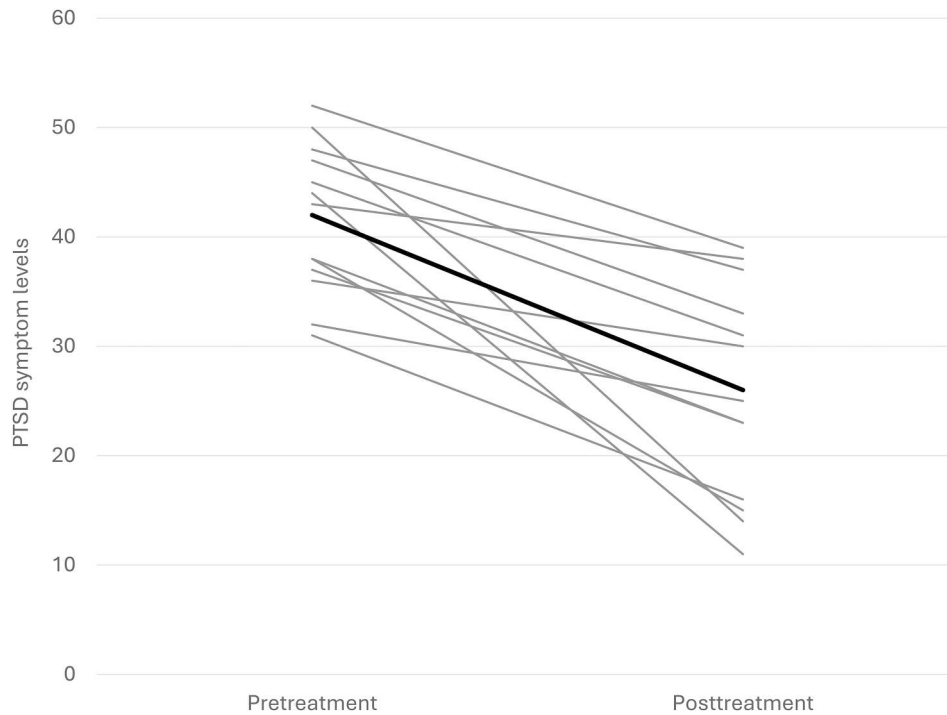


Figure 3. Change in PTSD symptom level from pre – to post-treatment ($n = 13$) (mean trajectory is indicated with bold line).

there's growing interest in self-monitoring for various physical and mental health conditions, we have limited knowledge about its effectiveness (Melbye et al., 2020). Additionally, while users often request personalization – such as choosing different voices for breathing exercises and customizing strategies – ‘personalization’ is a broad concept. It is challenging to assess its necessity or effectiveness (Hornstein et al., 2023) because we currently lack a clear definition of helpful personalization, and substantial evidence to guide decisions how to use it, apart from user input.

Our results indicate that implementation of several of the components of TF-CBT could be helped by features in an app. Both adolescents and therapists found app features such as psychoeducation, breathing exercises, identifying and describing a safe place, goals setting, and self-monitoring of symptoms to be useful. Therapists integrated the app into their therapies to varying degrees, with some introducing it early in therapy, while others encountered challenges due to time constraints and competing priorities. Nonetheless, the app was recognized as a valuable bridge between therapy sessions and daily life, offering support and a sense of security for patients, and a helpful tool for therapists who could use the app and data from the app to initiate conversations.

Interpreting reports on the use of individual app features presents a challenge due to their diverse nature and usage patterns. Some features, such as psychoeducation, are typically used only once, while others, like breathing exercises, are designed for repeated use. However, once patients have learned a breathing exercise, they may implement the technique

without reopening the app. Consequently, the frequency of feature use may not accurately reflect its usefulness (Hensler et al., 2021).

The opportunity to use the app when needed in daily life was noted as a strength, and several adolescents and therapists mentioned this as a particularly useful feature. Our impression is that many adolescents were positive to using the app to support their treatment. However, not all therapists integrated use of the app with the treatment, and the integration with treatment seems to be more challenging. This requires that the therapists are well acquainted with the features of the app and how to implement it. The interviews revealed that some therapists did not know what the content of the app was and what opportunities it could give them. Some therapists only showed the app to the adolescent in an early session (particularly connected to the component coping with stress), and then did not use it or ask about it in later sessions. The lack of therapist use of the app may have been caused by some therapists having a long delay between the training session on how to use the app and starting TF-CBT with an adolescent.

We expected that the therapists would check in on their patients' daily progress in the app every session, however, this was not the case. Some therapists explained that they considered the app to be private to the adolescents: they seemed to see the app as akin to a diary and did not want to pry into its contents. Being in treatment often involves sharing intimate details from one's life with a therapist, and the treatment may benefit from the therapist having correct information on the adolescent's daily struggles.

One therapist mentioned that their patient embellished the truth, and that this became evident only when they looked at the graph. Thus, treatment with adolescents may involve negotiating trust and privacy, and this might be particularly important when the therapist aims to use progress monitoring during treatment.

Implementing routine outcome monitoring in the treatment of adolescents is challenging (van Sonsbeek et al., 2021). Using frequent (e.g. daily) measures of symptoms as part of treatment is quite new and we currently have little experience in how to make the assessments useful for treatment. Several studies have examined therapists' and adult patients' perceived advantages and disadvantages of using frequent assessments in treatment (Bos et al., 2019; Bos et al., 2020; Frumkin et al., 2021; Piot et al., 2022; Weermeijer et al., 2023). Commonly mentioned advantages are that this could provide additional information that cannot be collected by other means which may provide the patient with more insights into their challenges. However, answering questionnaires daily or even many times each day may be burdensome, and therapists in these studies expressed difficulties in how to interpret and use these data. Thus, using technology to assess symptoms frequently shows promise, but how to realize this potential into actual utility is currently unclear.

Among the 13 participants who provided post-treatment data, there was a significant decrease in PTSD symptoms (PTSS). The proportion of those with probable DSM-5 PTSD declined from 88% before TF-CBT to 29% after the treatment. Our results showed that the reduction in PTSS was comparable to changes observed in traditional TF-CBT without app access. These findings are also consistent with results from another study, which found no additional benefit of using the PTSD Coach app as a complement to treatment (Possemato et al., 2023).

It is important to note that the main objective of the current study was not to evaluate the app's effect. Assessing any additive benefit of the app alongside a proven intervention like TF-CBT would require a more rigorous scientific design, greater resources, and a larger sample size (Fuhrmann et al., 2024). Moreover, adolescents in the target group of this app are already receiving evidence-based treatment. Adding an app does not seem to save resources or increase effectiveness; in fact, implementing the app could demand significant effort (Bear et al., 2022). This raises concerns about the practicality and value of researching and implementing apps to complement evidence-based treatments. The effectiveness of an intervention likely depends less on the delivery method and more on the extent to which the essential treatment principles are implemented. Whether strategies for emotional regulation or exposure

components are provided in therapy sessions or through an app seems less relevant, as long as they are accessible and usable for the adolescent. This makes it challenging to discern the additive effect of using an app.

Additionally, the usefulness of conducting a randomized controlled trial (RCT) on technological interventions may be limited. Given the rapid pace of technological development, research may become outdated by the time trial results are published (Mohr et al., 2015). Nonetheless, further research exploring various types of blended care and the optimal integration of technological interventions with therapist support would provide valuable insights into how this could reduce drop out and be more effective than traditional treatment.

The study has some strengths and limitations. This is one of the first studies to develop and test out an app as support for evidence-based treatments, more specifically for TF-CBT targeting adolescents. We employed a mixed methods design to gain insights into how best to design the app and assess its usage. A notable strength of our approach was interviewing both adolescents and therapists as users, to gather input on the content and their experiences with the app. This inclusive approach ensured that diverse perspectives informed the app's development, enhancing its relevance and usability.

We faced several challenges related to data collection and the implementation of TF-CBT, including dropout from TF-CBT and difficulties in collecting data from therapists and adolescents. These challenges are consistent with those experienced from 10 years of implementing and conducting naturalistic clinical research on TF-CBT (Skar et al., 2022). These factors limited our sample size and may have affected the representativeness of our results. Moreover, our study was not a randomized controlled trial, which prevents us from making definitive conclusions about causal effects. We did not gather information from a representative sample of patients, thus leaving us unsure if other patients would use the app in similar ways. Finally, because participants in this study were incentivized with gift cards, we cannot ascertain whether the results would generalize to adolescents using the app in regular clinical settings.

In conclusion, the app 'My everyday life' seem to be useful for youth who receive TF-CBT, particularly if their therapists take the time to get to know the app and how to use it. The therapists may benefit from clearer guidelines on how to use apps in practice together with evidence-based treatment. The current study was not powered to assess whether the app undermine or increase the effect of TF-CBT. Thus, we cannot provide a strong recommendation for using this app with every patient. However, the app can be useful for adolescents who are motivated by

using digital tools for coping or tracking their own progress. Clinicians should consider the individual preferences and motivation levels of their patients when deciding whether to incorporate the app into their treatment plan. For these adolescents, the app can facilitate the learning of strategies proposed by TF-CBT, potentially enhancing engagement and adherence to the therapeutic process. This highlights the app's role as a supplementary tool rather than a stand-alone treatment. The app is currently only available in Norwegian, but can be made available for researchers who want to translate it.

This study also suggested that the app could be further developed by including more functions, perhaps tightly connected to the components of TF-CBT. This could make it easier for therapists to use the app to support implementation of specific TF-CBT components. Further developments of this or other apps might benefit from utilizing persuasive design principles (McLean, 2020). We need to better understand how to integrate an app in treatment in ways that are useful and that add something to current practices. Further research could explore different models of blended care that combine technological interventions with therapist support and identify the combinations that are both effective and time efficient. We also need to understand more about the optimal balance between the burden placed on patients to routinely document their progress and the therapeutic benefits derived from such monitoring.

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