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A review of design characteristics of cognitive behavioral therapy-informed behavioral intervention technologies for youth with depression and anxiety

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Abstract

Objective: Cognitive behavioral therapy (CBT) has the strongest evidence base for the prevention and treatment of depression and anxiety in youth. Behavioral intervention technologies (BITs) provide an opportunity to overcome access barriers to traditional delivery of CBT. The present review evaluates the design characteristics of CBT-informed BITs for depression and anxiety designed for and tested with youth.

Methods: A state-of-the-art review of three library databases (PubMed, Scopus, and Web of Science) was conducted to identify papers that evaluated the use of CBT-informed BITs for the prevention and/or treatment of depression and anxiety among youth. Narrative results of design characteristics were organized using the BIT model, which provides a framework for design and evaluation.

Results: 219 unique results were retrieved through the search. After review, 14 papers (4 prevention and 10 treatment) met the selection criteria. A broad diversity occurred in reporting the design and methodology of CBT delivered to youth through BITs. Psychoeducation was overwhelmingly utilized as the primary change strategy throughout the interventions, with a heavy use of content delivery elements and linear workflows. The reporting of sample characteristics was minimal and varied.

Conclusions: Providing psychoeducation via content delivery was the most utilized BIT change strategy in the interventions, likely limiting the use of multiple BIT elements or flexible workflows. While characterizations could be inferred from the current reports, the high level of variability in reporting is problematic. Generalizability becomes increasingly more difficult to carry out effectively without clear descriptions of the design for evaluated BITs.

Keywords

Cognitive behavioral therapy, behavioral intervention technologies, youth, anxiety, depression, treatment, prevention

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Introduction

Internalizing disorders, such as depression and anxiety, are common in pediatric populations. For example, 11% of adolescents experience a depressive disorder and 25% experience an anxiety disorder before age 18 in the United States.[1] Worldwide, anxiety disorders are the most frequently experienced mental health condition for youth, followed by behavior and mood disorders (e.g. depression).[2] Depression and anxiety symptoms in youth (i.e. 21 years and under), even

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when below the diagnostic threshold, are associated with a broad range of psychopathology and impairment that may persist into adulthood.[3–6] Cognitive behavioral therapy (CBT) is the most studied psychotherapy for the prevention (i.e. intervention targeting symptoms prior to the occurrence of a disorder) and treatment (i.e. intervention targeting full-criteria symptoms of a disorder) of depression and anxiety in youth, and carries the strongest body of evidence for its effectiveness.[7–9]

Despite the efficacy of CBT for internalizing disorders such as depression and anxiety, access to these interventions is limited. While there have been recent increases in diagnoses of internalizing disorders in youth,[10] estimates indicate that only a small portion of symptomatic children and adolescents receive any treatment.[11,12] Indeed, those with a severe presentation are most likely to receive services,[2] and while school services may provide a point of entry for care, few transition to specialty services.[13,14] Even among those who do receive care, most only receive a handful of sessions, which is inadequate to address the problems.[12] Further, racial and ethnic disparities persist in the treatment and prevention of internalizing disorders in youth,[12,15–17] with concerns of stigma, lack of access to effective services, and financial burden cited as primary barriers.[18,19] Given these barriers and disparities for children and adolescents, current needs for mental health care therefore cannot be met with traditional, one-on-one intensive treatment and preventive interventions.[20]

To meet population needs for mental health treatment, behavioral intervention technologies (BITs) are increasingly becoming accepted as a delivery platform. BITs employ technologies (e.g. mobile phones, tablets, computers, sensors, etc.) to support behavior change related to health, mental health, and overall wellness.[21] Mobile and smartphone health apps, treatment and prevention websites, sensors used in activity trackers, and smartwatches are common examples of BITs. The term BIT is used, rather than eHealth or mHealth, as these terms can reflect a much broader area of medicine and informatics not necessarily focused on behavior change (e.g. electronic health records fall under the umbrella of eHealth or mHealth).[22] BITs offer the possibility to deliver interventions by overcoming many of the previously mentioned barriers.

Multiple reviews and meta-analyses examining trials of BITs for youth with internalizing disorders have shown these interventions to be generally effective and acceptable.[23–29] However, the designs of these interventions (i.e. the execution of intervention aims through specific elements, characteristics, and workflows of BITs) have not been considered collectively. This is problematic, as design likely plays a key role in uncovering what types of BITs are most efficacious, for which populations, and under which circumstances.[30] Therefore, a state-of-the-art review of the design of recently evaluated BITs for youth with internalizing disorders would enrich the field's understanding of the design choices operationalized in efficacious interventions,[31] as well as areas to target for improvement.

Grounding BIT design in a framework

BITs that deliver interventions to youth tend to result from a multi-disciplinary collaboration with differing design needs and goals. For example, encompassed within the design of these BITs are a variety of requirements, ranging from the behavioral change strategies involved in CBT, to usability principles to ensure that the BITs technically function the way they were intended.[32,33] Grounding the current design literature into a framework that considers these different needs provides a more nuanced and complete understanding of the design of these BITs. Multiple models currently exist to frame the current work. One example is the Ritterband behavior change model for internet interventions, a generalizable model intended to identify how internet interventions contribute to behavioral change.[34] While the Ritterband model could be extended to technologies outside of the web (e.g. mobile), a limitation for the current evaluation is that the model neglects to map design components onto specific intervention goals (i.e. target depression and anxiety). Another possible model is Fogg's behavior model for persuasive design, which focuses upon motivation, ability, and triggers to facilitate minor behavior change(s).[35] However, BITs targeting internalizing disorders tend to focus on larger behavioral change (i.e. targeting a cluster of anxious and depressive symptoms rather than one aspect), making the smaller behavioral change emphasized in the Fogg model a poor fit for the current review. The BIT model, however, integrates behavioral science, engineering, and design to translate specific clinical aims into BIT design.[36] While there are a growing number of models to consider the design of BIT interventions, the BIT model provides a helpful framework to review the design practices of recently evaluated BITs for youth with internalizing disorders.

The behavioral intervention technology model

The BIT model defines BITs in terms of the "why," "how," "what," and "when," to support the translation of clinical aims and behavioral strategies into BIT technologies.[36] This model is useful both for the design and definition of BITs,[37,38] as well as for literature reviews.[39] The BIT model has two broad levels: a

theoretical action level, which represents the intentions of the developer or researcher, and an instantiation level, which represents the technological implementation.[36] The theoretical level includes two levels: (1) "why" the BIT exists is encompassed in the intervention aims (including clinical aims, usage aims, and subaims) and (2) "how" the BIT will conceptually achieve those aims is comprised of the behavioral strategies.[40] The instantiation components include three items: (1) "what" is delivered to users (i.e. BIT elements, distinct objects of a BIT with which the user interacts); (2) "how" elements are delivered (i.e. their characteristics); and (3) "when" elements are delivered to users, in what sequence, and for how long (i.e. workflow).[36]

Purpose

The purpose of this review is to provide a state-of-the-art review regarding the design of CBT-informed BITs for the treatment and prevention of internalizing disorders among youth.[31] Design characteristics will be organized under the framework of the BIT model.[36] Secondarily, as cultural adaptations of the interventions (i.e. framed under the "how" of characteristics of a BIT in the BIT model) were rarely specified, this review will also examine the reporting of samples to enrich the insight into design decisions presented in the current body of literature.

Methods

Searches were performed in May 2015 in the following databases: PubMed MEDLINE (1940s–), Scopus (1823–), and Web of Science (1900–) for articles related to delivering CBT-informed BITs to youth for the prevention and/or treatment of depression and anxiety. For the database searches, six main search components (internet, web-based, interventions, cognitive behavioral therapy, pediatric, child) were created by combining subject headings with the "AND" or "OR" operators. No date or language limits were applied to the searches; however, papers that were not in English were later excluded. Reference lists of relevant articles were screened for further potentially relevant studies.

Papers were included based on the following criteria: (1) reported on the evaluation of a BIT for the prevention and/or treatment of anxiety and/or depression; (2) the target population was children or adolescents (i.e. the sample consisted of youth 21 and under); (3) used the BIT to deliver treatment; (4) the BIT was designed using a cognitive behavioral intervention framework; (5) included a sample >5 participants (i.e. to limit the inclusion small pilot trials or case studies); and (6) the paper was in English. Papers were excluded if they: (1) targeted parents or adults as identified patients (i.e. perinatal or parent management skills training); and (2) used telephone or videoconferencing exclusively, rather than CBT delivered via a BIT.

Data extraction

Given the aims of this state-of-the-art review and the small number of studies in this area, study reports were examined for narrative information on design, rather than formal quantitative or qualitative analyses. Data were extracted by the first author and reviewed by the second and third author for accuracy using the BIT Model as an organizing framework (i.e. "why: intervention aims," "how: behavior change," "what: elements," "how: characteristics," and "when: workflow"). Given their aims at intervening with youth above (i.e. treatment) and below (i.e. prevention) the diagnostic threshold for a depression or anxiety diagnosis, the prevention and treatment literature likely had differences that would implicate distinct designs (e.g. differing clinical goals, behavioral strategies, etc.). The prevention and treatment interventions were therefore presented separately in the present review.

Results

Figure 1 displays the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart. The search produced 219 unique results retrieved from the database searches. Titles and abstracts were reviewed for relevance of these unique results, and 19 articles had full-text review for inclusion or exclusion from this work. The review resulted in 14 articles meeting inclusion and exclusion criteria for inclusion in the final analysis. Table 1 displays the sample characteristics and study design for each of the papers reviewed, which included trials of four prevention interventions and 10 treatment interventions.

Sample characteristics

The studies included children and adolescents ranging in ages from 8 to 21 years; however, the majority focused on the age range 12–17 years. Most study samples included a majority of females, with the percent of females ranging from 25–86%. Of note, one treatment intervention study did not report gender inclusion.[47]

Cultural adaptations of the designs were not reported. Further, racial and ethnic minority inclusion was not consistently reported. In the prevention literature, three out of the four papers included did not specifically indicate minority inclusion.[41,42,44] Of all of the studies reviewed, the most detailed description of the demographic make up of the sample was Project CATCH-IT, which broke their sample into groups of

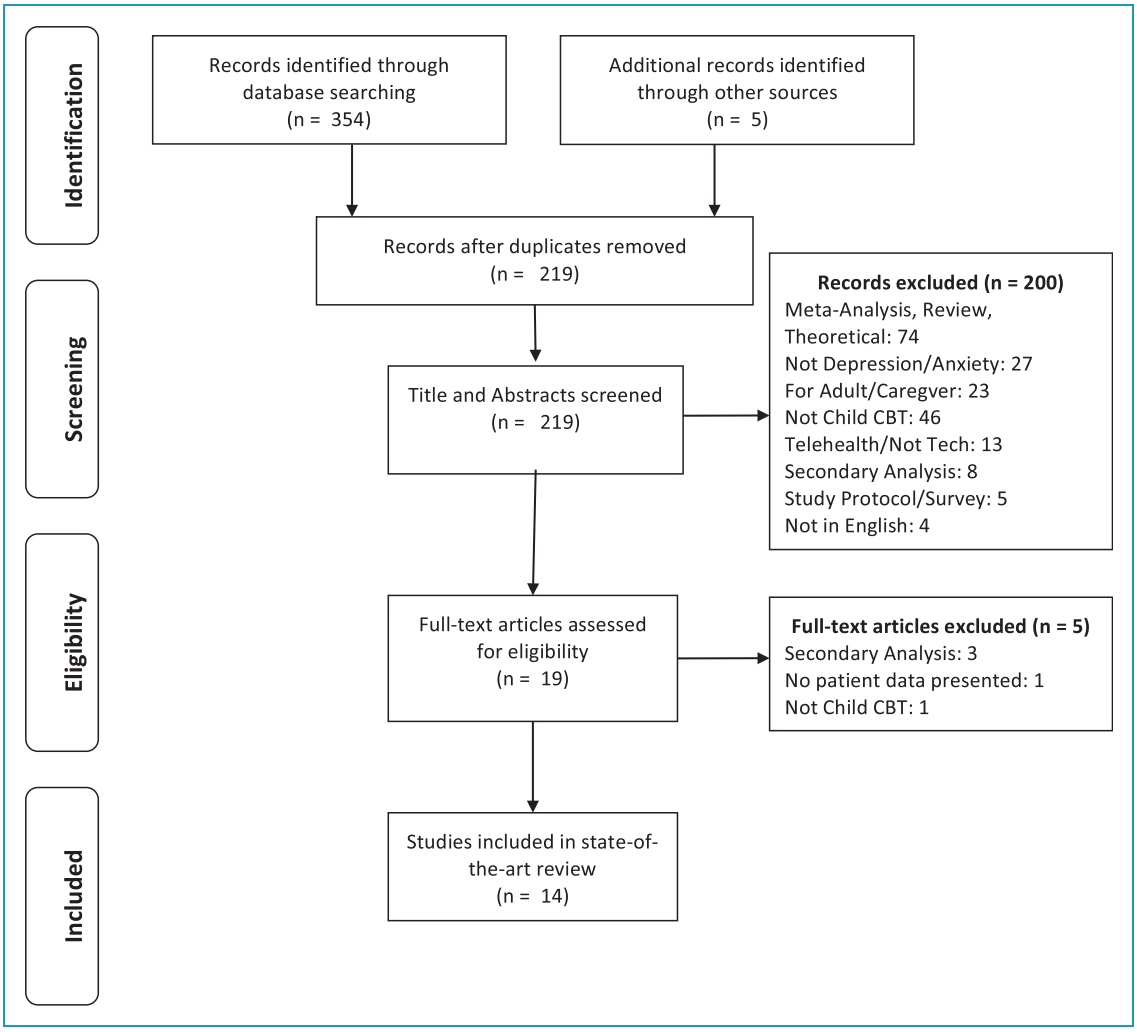

Figure 1. PRISMA flow diagram for study inclusion.

White, Black, Hispanic, Asian, Native American, and other.[43] In the treatment literature, four of the ten papers described minority status by being born outside of the country of study execution (i.e. "25.6% non-Australian"),[46,49,51] and the other six did not report racial and/or ethnic minority status.[45,47,48,50,52–54]

Design characteristics of CBT-informed BITS

Table 2 portrays the findings of the review of design characteristic organized by the BIT model.

Why: intervention aims. All studies depicted the clinical intervention aim as a reduction of target symptoms (or maintenance, in the case of prevention) in youth, with only one study explicitly stating a sub-aim. Two of the prevention studies reviewed targeted depression only: MoodGYM (Norway) and Project CATCH-IT;[41,43] and two of the trials targeted depression and anxiety: MoodGYM (Australia) and ThisWayUp Schools.[42,44] Six of the 10 treatment studies targeted anxiety disorders: BiP OCD, SmartCAT, DARE Program, BRAVE for Teenagers Online, Cool Teens, and iCBT for Social Anxiety Disorder.[38,42,43,45,50,51] Targets of anxiety included: Generalized Anxiety Disorder, Social Phobia, Separation Anxiety Disorder, Specific Phobia, Obsessive Compulsive Disorder, and Social Anxiety Disorder. Three of the treatment studies aimed to treat depression only: Stressbusters, The Journey, and SPARX;[45,49,53] one intervention, Think, Feel, Do, targeted both depression and anxiety.[48] Only one study, MoodGYM (Norway), explicitly stated a clinical sub-aim for depression prevention, which was to increase self-esteem.[41] While it is likely that other studies had clinical sub-aims, they were not stated in the articles.

Usage aims are encompassed within intervention aims of a BIT. While usage aims were implied, no

Table 1. Study design and sample characteristics of papers included in this review.

	Study design	*n*	Sample	Country	Ages	Gender (% female)	Reporting of racial/ethnic minority status
Prevention: *Pilot/feasibility studies*							
Lillevoll et al.,[41] ''MoodGYM''	Four-arm RCT. Randomly allocated to MoodGYM with a tailored weekly email reminder vs. MoodGYM with standardized weekly email reminder vs. MoodGYM with no email reminder vs. waitlist control	707	School	Norway	15–20	56.80%	Not reported
Prevention: *Randomized trials*							
Calear et al.,[42] ''MoodGYM''	RCT comparing Treatment vs WLC	1477	School	Australia	12–17	55.90%	Not reported
Van Voorhees et al.,[43] ''Project CATCH-IT''	RCT comparing physician motivational interviewing (MI) + Internet program vs. brief advice (BA) + Internet program	84	Clinic	United States	14–21	56.60%	40% non-white
Wong et al.,[44] ''ThisWayUp Schools: Combatting Depression and Overcoming Anxiety''	Three-arm cluster RCT: anxiety or depression school-based intervention vs. school-based TAU.	976	School	Australia	14–16	70%	Not reported
Treatment: *Pilot/feasibility studies*							
Abeles et al.,[45] ''Stressbusters''	Single arm field trial	28	Clinic	United Kingdom	12–16	85.70%	Not reported
Lenhard et al.,[46] ''BiP OCD''	Single arm field trial	21	Clinic	Sweden	12–17	61.90%	4.8% other European outside of Sweden.
Pramana et al.,[47] ''SmartCAT''	Feasibility study: 16-sessions of CBT vs. 8-sessions of Brief CBT; both groups provided with workbooks and smart phone with SmartCAT app	9	Unknown	United States	9–14	Not reported	Not reported
Stallard et al.,[48] ''Think, Feel, Do''	Pilot RCT, comparing 6-session computerized CBT vs. WLC	20	Clinic	United Kingdom	11–17	25%	Not reported
Stasiak et al.,[49] ''The Journey''	Double blind RCT, comparing an active program with CBT content (cCBT) vs. a control attention placebo program with psychoeducational content (CPE)	34	School	New Zealand	13–18	41%	29% non-European

(continued)

Table 1. Continued.

	Study design	*n*	Sample	Country	Ages	Gender (% female)	Reporting of racial/ethnic minority status
Vigerland et al.,[50] "DARE Program"	Single arm field trial	30	Community	Sweden	8–12	57%	Not reported
Treatment: *Randomized trials*							
Spence et al.,[51] "BRAVE for Teenagers ONLINE"	Three-arm RCT comparing 12 weeks of Internet-based CBT Treatment (NET) vs. Clinic-based CBT treatment (CLIN) vs. wait list control	115	Clinic	Australia	12–18	59.10%	9% born outside of Australia
Wuthrich et al.,[52] "Cool Teens"	RCT comparing computerized CBT vs. WLC	43	Community	Australia	14–17	63.80%	25.6% non-Australian
Merry et al.,[53] "SPARX"	RCT comparing computerized CBT vs TAU	187	Clinic	New Zealand	12–19	65.80%	Not reported
Tillfors et al.,[54] Internet-delivered treatment for SAD	RCT comparing Internet-delivered CBT vs. WLC	19	School	Sweden	15–21	89.5%	Not reported

paper explicitly stated usage targets (e.g. daily, 2 × per week, weekly). However, two prevention studies included an evaluation of methods of increasing usage. The MoodGYM (Norway) study hypothesized that emailed tailored feedback (which is considered a BIT element) would enhance initial uptake and adherence to the intervention, while CATCH-IT hypothesized that the primary care physician's approach (Motivational Interviewing vs. Brief Advice) would influence participants' usage of the internet intervention. No treatment studies provided information on expected usage.

How: behavior change strategies. The prevention trials all emphasized the use of psychoeducation as change strategies. The prevention psychoeducation covered topics related to: symptom recognition,[44] identifying problematic or dysfunctional thinking patterns,[41–44] challenging thoughts,[41,43] problem solving,[43] increasing pleasant activities,[41,43,44] stress reduction,[42] interpersonal relationship management skills,[41–43] and issues covered in manuals for interpersonal therapy (IPT), behavioral activation (BA), and a community resilience model.[43] To reinforce this learning, modeling through the presentation of fictional characters was used in three studies,[41,42,44] and one used quizzes and homework.[42] Further, two studies engaged additional people in the youths' networks, one using parents to reinforce behavior change,[43] and the other using teachers and classroom engagement around intervention content facilitated by a teacher.[44]

While all 10 of the treatment trials included psychoeducation commonly related to CBT manuals, eight reports explicitly stated the topics covered in the interventions. Treatment psychoeducation topics included goal setting,[45,50,52] emotion recognition,[45,48,51,54] scheduling and increasing pleasant activities,[45,49,53] identifying distorted or negative thoughts,[45,48,49,51,53,54] challenging thoughts, [45,48,49,51,53] problem solving skills, [45,48,49,51,53] improving social interactions,[45,49,53,54] relaxation techniques,[49,51,53] exposure hierarchies and/or graded exposure information,[50–52,54] coping strategies and reward systems,[50] and relapse prevention.[45,49,50,53,54] Psychoeducation was sometimes enhanced through quizzes and exercises,[48] and more commonly through homework assignments.[48,49,51–53]

Modeling as a change strategy was used in five treatments through case vignettes and videos.[45,48,51–53] Additionally, two interventions provided electronic records to aid users in completing exposures, a common technique in which one attempts planned interactions with situations or environments that are likely to increase anxiety.[47,51] Reinforcement through gamification was used to promote usage in The Journey.[49]

Table 2. Review of design characteristics according to the BIT model.

	WHY: intervention Aims						
	Clinical aim: depression	Clinical aim: anxiety	Usage aim	HOW: Behavior change strategies*	WHAT: BIT Elements**	HOW: Characteristics of BIT	Platform
Prevention: *Pilot/feasibility studies*							
Lillevoll et al.,[41] "MoodGYM"	✓ with sub aim: self esteem		✓	Modeling through fictional characters			Desktop computer
Prevention: *Randomized trials*							
Calear et al.,[42] "MoodGYM"	✓	✓		Modeling through fictional characters, quizzes, homework			Desktop computer
Van Voorhees et al.,[43] "Project CATCH-IT"	✓		✓				Desktop computer
Wong et al.,[44] "ThisWayUp"	✓	✓		Modeling through fictional characters			Desktop computer
Treatment: *Pilot/feasibility studies*							
Abeles et al.,[45] "Stressbusters"	✓			Case vignettes and videos	Interactive exercises	Narrated video	CD-ROM
Lenhard et al.,[46] "BiP OCD"		✓ OCD		Homework	Interactive exercises	Films and web based exercises	Desktop computer
Pramana et al.,[47] "SmartCAT"		✓		Exposure via electronic records	Messaging, notifications, media library, reward bank	In-moment notifications with a dialog of title, message, and action button	Android compatible Smart phone app
Stallard et al.,[48] "Think, Feel, Do"	✓	✓		Quizzes and exercises, homework, case vignettes and videos		Video	CD-ROM
Stasiak et al.,[49] "The Journey"	✓			Gamification, homework, quizzes and videos	Interactive fantasy game	Video, interactive exercises, mini games	CD-ROM
Vigerland et al.,[50] "DARE Program"		✓ Specific phobia					Desktop computer

(continued)

Table 2. Continued.

	WHY: intervention Aims						
	Clinical aim: depression	Clinical aim: anxiety	Usage aim	HOW: Behavior change strategies*	WHAT: BIT Elements**	HOW: Characteristics of BIT	Platform
						Films, interactive exercises, internet based	
Treatment: *Randomized trials*							
Spence et al.,[51] "BRAVE for Teenagers ONLINE"		✓		Homework, case vignettes and videos, exposure	Automated emails	Interactive exercises, internet based	Desktop computer
Wuthrich et al.,[52] "Cool Teens"		✓		Homework, graded exposure, case vignettes and videos		Audio, live video	CD-ROM
Merry et al.,[53] "SPARX"	✓			Gamification, homework, case vignettes and videos	Interactive fantasy game	Game with avatar and guide	CD-ROM
Tillfors et al.,[54] Internet-delivered treatment for SAD		✓ Social Anxiety Disorder		Exposure	Therapist emails		Desktop computer

*All interventions reviewed included psychoeducation.
**All of the interventions reviewed included content delivery as a BIT element, and text-based information, as a BIT characteristic, apart from Pramana et al.,[47] "SmartCAT." The WHEN: Workflow of BIT for all the interventions reviewed were sequential and linear, apart from Van Voorhees et al.,[43] "Project CATCH-IT," where workflow was not mentioned, and Pramana et al.,[47] "SmartCAT," where workflow was "as needed."

What: BIT elements. The prevention studies relied exclusively upon content delivery elements, which enabled exposure to psychoeducational materials through 5–14 modules across studies. These content delivery elements were text-based lesson content.

Lesson content delivery was also used for the treatment studies, through the use of paper and electronic content delivery.[45,48–50,54] Four relied exclusively on content delivery, while the remaining used a variety of elements, including messaging portals,[47,50] notifications,[47] media libraries,[46,47,50,52] and visualizations of reward banks (i.e. users accrue points that may be exchanged for rewards).[47]

Two BITs were designed as interactive fantasy game elements. Only one of the trials consisted of a first-person fantasy game intervention (i.e. the perspective on the screen is rendered as if from the view point of the player),[53] with the other described as a fantasy game-like environment without a description of the point of view.[49] However, both of these interventions, SPARX and the Journey, also included didactic content in the form of paper workbooks.[49,53]

How: characteristics. The study reports provided little detail on the characteristics of the BITs in terms of level of complexity of graphics, designs, etc. When descriptions did occur, they were vague (i.e. ''Eye-catching graphics, sounds, games, and quizzes are used to maintain the adolescents' level of interest'') and were therefore difficult to review.[51] We therefore focused on the choice of platform for delivery of the interventions.

Among the prevention studies, one was delivered exclusively through an internet platform,[44] with the rest using both an internet platform supplemented with paper worksheets [44], youth workbooks,[41] and parent workbooks.[43] All but one of the treatment interventions utilized a BIT as the main delivery of treatment. The exception was the smart-phone enhanced child anxiety treatment (SmartCAT) intervention platform, which was utilized as an adjunct to face-to-face treatment.[47] Half of the treatment interventions' main platforms were CD-ROM,[45,48,49,52,53] however, only one study relied solely on a CD-ROM platform, without any supplements from paper handouts or guidebooks, or therapist interaction.[48] Four included BITs deployed online,[46,50,51,54] with BRAVE for Teenagers Online and BiP OCD utilizing an internet platform.[46,51] SmartCAT used the most platforms, with face-to-face treatment, a paper workbook, internet dashboard for the clinician, and mobile app for in-the-moment interventions and monitoring.[47] No mobile phone native apps were used in this group of studies.

When: workflow. The workflow of the prevention interventions involved a linear progression, in which content was released to the participant using time-based rules (i.e. new content each week), or a recommended number of modules to complete per week, in order.[43] Half of the treatment articles indicated a linear, time-based progression rule,[45,48,49,51] with the remaining studies not reporting progression rules.

Settings and support provided beyond the BITs

While not included as part of the BIT model, settings and support provided for study participants were emphasized in the methodologies of the reports. Three of the prevention trials were conducted in the context of school systems. Indeed, three of the trials were school-based interventions,[41,42,44] with one of those involving teachers leading group discussions about the intervention content.[44] One of the four prevention studies was based in primary care and utilized the Primary Care Physician for support. The trial also targeted parents, and included interpersonal therapy (IPT) and behavioral activation (BA) in addition to CBT to ground the behavior change strategies.[43]

The majority of treatment intervention reports indicated support provided in the adolescents' use of the BITs. Six reports indicated concurrent clinician support throughout the treatment period.[45,46,50–52,54] This is in contrast to SmartCAT, in which the BIT was an adjunct to face-to-face therapy delivery with a therapist.[47] Parental support was also a common feature, with four studies providing parent materials and encouraging parental engagement with the teen users around the treatment interventions.[46,50]

Discussion

The present paper aimed to review the design characteristics of CBT-informed BITs for the prevention and treatment of depression and anxiety in youth, as well as characterize the samples that have been evaluated. Consistent with CBT, the BITs employed behavioral strategies to broadly reach the clinical aims of treating or preventing internalizing disorders. Providing psychoeducation via content delivery was overwhelmingly the most utilized BIT change strategy in the interventions. This emphasis limited the amount of BIT elements utilized, with few interventions describing use of other technological affordances. Further, few details were provided about the characteristics of the BITs beyond the statement of the delivery platform, which included a surprisingly heavy use of CD-ROM or static program delivery. Also perhaps related to the nature of psychoeducation, much of the workflows progressed in a linear fashion, when described. Usage aims were not articulated. Finally, a high number of discrepancies in

reporting of sample characteristics and methodology made generalizing difficult across studies.

Targets of depression and anxiety were addressed with psychoeducation as the primary behavior change strategy. Therefore, content delivery elements were prevalent across studies. This is of note, as there are a large number of potential behavioral strategies,[55,56] which might be instantiated via a variety of newer technologies in future research. For example, current software technologies now allow BITs such as mobile apps to be fully interactive, as well as responsive to other built-in functionalities, such as sensors to determine patient contexts.[57,58] mHealth apps are increasingly capable of connecting to an outside sensor or device.[59] For example, features using GPS data can measure the amount and pattern of activities related to depression,[58] which could initiate behavioral activation strategies. For anxiety, many wearable devices now contain sensors that can detect stress (e.g. heart rate, galvanic skin response, etc.),[60,61] which might be used to trigger recommendations for emotion regulation and relaxation strategies. While heavy reliance on content delivery elements may have been due to the state of technology at the time of development and deployment, the growing technological affordances offer an increasingly large number of opportunities to instantiate behavioral strategies in BITs.

The delivery mechanisms reported were varied and often outdated, even by the time of publication. For example, five treatment trials utilized CD-ROMs and eight required use of a desktop computer to connect to the online platform. While one intervention integrated a smartphone app, no native apps were evaluated. To some extent, this can be expected given how quickly technology platforms advance and the need to create inexpensive, minimally viable products for early testing. However, youth are notoriously sensitive to methods that are perceived to be outdated.[62] This speaks to the need to investigate the possible benefits of framing trials as experiments testing intervention principles, rather than products, which will likely be outdated by the time of publication.[63] We have articulated here a way of thinking about these principles using the BIT model as a framework; with theoretical action components being the clinical aims and behavioral strategies, which are then instantiated through technological components. Thus, even when technology moves ahead, the efforts of researchers may be more likely to produce generalizable knowledge that could benefit the field.

Workflow provides an example of how BIT research may shift towards evaluating principles, rather than specific technology. The workflow of elements, when described in this literature, involved primarily linear progressions. As a variety of behavior change approaches may be delivered via technology, future research may investigate whether youth prefer and highly utilize user-defined workflows, in which users decide what to access, and when (i.e. "freedom of choice").[64,65] This flexibility in workflow is more consistent with current technologies, such as apps, wherein users tend to select the order, timing, and frequency they interact with different elements.[59] Future research may also explore flexibility in workflow desires based upon developmental stage.[66] For example, researchers may shift a focus in workflow based on developmental principles, such that the developmental stage of the user may determine reinforcement schedules (i.e. greater frequency for younger users) or anticipated duration of interactions (i.e. shorter interactions for younger users).[66] Shifting to testing principles would enable researchers to identify effective design processes rather than evaluating the workflow of a specific product. As future designs explore different behavioral change techniques with varying elements, evaluating principles, such as workflow needs based on developmental stage, will likely promote generalizable knowledge without relying on evaluation insights from an aging or outdated technology.

Despite two studies explicitly noting targets believed to impact overall usage (i.e. emailing tailored feedback and physicians engaging in motivational interviewing), usage aims were generally not explicitly stated in the reports. The problem of comparability of usage will only increase as the variety of platforms (i.e. web vs. phone, vs. wearable) and interactions increases. Clearly stating usage aims therefore has two potential benefits. First, usage aims may be useful in defining usage metrics in a manner that can be comparable across studies, such as a ratio of actual use to expected use. For example, a usage metric would make comparability possible across interventions that are intended to be used daily, weekly, as needed, etc. Second, usage aims are frequently the basis for identifying intervention features that are not performing adequately and may require improvement.[63] Stating usage aims may increase comparability and highlight issues of usability.

None of the studies reported that a design model was used, which is understandable given the pace of trials, and the recent release of the BIT Model and similar models.[34–36] However, applying a theoretical and instantiation model to the existing studies demonstrated the high number of discrepancies in the manner through which design may be reported. Given the limited space to report design methodologies, more information pertinent to design and implementation decisions may have been sacrificed. This is particularly likely for clinical audiences more interested in symptom-related outcomes. Future evaluations of CBT delivered through BITs to youth would likely benefit from the use of an appropriate design model, such as

the BIT model.[36] Additionally, the application of the model, design characteristics, and execution must also be accessible (e.g. detailed in the published results or in an appendix) to promote generalizability and comparability to other BIT reports.

Finally, BIT developers frequently argue that as a delivery mechanism, BITs have the capability of overcoming access and health disparity barriers. This is reflected in the current literature, as the argument that BITs overcome emotional, practical, or symptom-based barriers to treatment was made in the introduction of each reviewed report. However, cultural adaptations and the samples participating in these interventions were poorly defined. A recent review of health and wellness technology use by historically marginalized and underserved populations indicated that while technology may positively impact the health of such groups, it must be tailored for the group to be personally relevant.[67] Future BIT designs might therefore be improved through greater transparency of cultural adaptation and/or clear definition of sample characteristics.

To the best of our knowledge, this was the first use of a model to frame a state-of-the-art review of the design characteristics of CBT-informed BITs for youth with internalizing disorders. However, limitations should be considered in the interpretation of these findings. Given the aims of this review, combined with the small number of studies in this area, the present review did not employ a double-rated systematic review, or a quality appraisal. Gray literature was also not included and only three search engines were utilized. Further, it reviewed narrative data without the use of a coding system or quantitative data. There are therefore possibilities of selection bias in this current review that should be considered. As this field grows, it will important to systematically review the resulting literature. This review was also limited in scope, focusing on the design of CBT-oriented interventions for youth with internalizing disorders. Future reviews should explore the characteristics of BITs for youth beyond internalizing disorders and CBT-orientations.

Conclusion

BITs provide clinicians and researchers with the opportunity to overcome barriers seen in CBT prevention and treatment programs for youth. The current body of evidence has characterized initial attempts to employ this delivery method. However, more research is needed. Without clear descriptions of how a BIT is designed to meet each level of the BIT model, or a similar design framework, generalizability and further evaluation become increasingly more difficult to do effectively. Future iterations of CBT-informed BITs may improve through the use of model and principle-driven designs with web and mobile platforms, and have transparency in descriptions of all design practices.

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