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Consumer smartphone apps marketed for child and adolescent anxiety: A systematic review and content analysis

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Abstract

Anxiety disorders are collectively the most prevalent mental health problems affecting youth. To increase the reach of mental healthcare, recent years have seen increasing enthusiasm surrounding mobile platforms for expanding treatment delivery options. Apps developed in academia and supported in clinical trials are slow to reach the consumer marketplace. Meanwhile, proliferation of industry-developed apps on consumer marketplaces has been high. The present study analyzed content within mobile products prominently marketed toward consumers for anxiety in youth. Systematic inventory of the Google Play Store and Apple Store using keyword searches for child and adolescent anxiety yielded 121 apps, which were evaluated on the basis of their descriptive characteristics, mobile functionalities, and adherence to evidence-based treatment principles. Findings revealed that evidence-based treatment content within the sample is scant and few comprehensive anxiety self-management apps were identified. Advanced features that leverage the broader functionalities of smartphone capabilities (e.g., sensors, ecological momentary assessments) were rarely present. Findings underscore the need to increase the prominence and accessibility of quality child anxiety intervention products for consumers. Strategies for improving marketing of supported apps to better penetrate consumer markets are discussed.

Childhood anxiety disorders constitute an enormous public health concern. In the U.S. alone, estimates indicate that anxiety disorders are collectively the most prevalent class of mental disorders and are among the earliest disorders to establish themselves, with median age of onset occurring at age 6 (Merikangas et al., 2010). Indeed, almost one in ten preschoolers suffer from an anxiety disorder before age 5 (Egger & Angold, 2006) and nearly one-third of adolescents experience anxiety disorder onset prior to age 18 (Merikangas et al., 2010). Furthermore, anxiety is related to a high degree of comorbidity with other mental health problems (Costello, Egger, & Angold, 2005) and a stable course across the lifespan. Clinical levels of anxiety during adolescence have been linked to a

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number of poor outcomes in adulthood, including increased risk for anxiety, depression, substance use, suicidal behavior, educational underachievement, early parenthood, and overall reduced quality of life (Comer et al., 2011; Woodward & Fergusson, 2001). Moreover, daily interference and impairment in those experiencing anxiety is high, and the nature of anxiety symptoms is linked to deficits in multiple domains of functioning, such as school absenteeism (Kearney, 2008), poorer social skills (Crawford & Manassis, 2011), sleep problems (Weiner, Elkins, Pincus & Comer, 2015), lower levels of peer acceptance (Greco & Morris, 2005), elevated substance use (Wu, Goodwin, Comer, Hoven & Cohen, 2010), and greater peer victimization (Crawford & Manassis, 2011; Siegel, La Greca, & Harrison, 2009). Early intervention for anxiety is critical.

The past several decades have witnessed tremendous advances in the development and evaluation of evidence-based treatments for anxious youth (Higa-McMillan, Francis, Rith-Najarian, & Chorpita, 2016). Cognitive-behavioral therapy (CBT) has received the strongest support in clinical trials and is considered the “gold-standard” psychosocial intervention for anxiety disorders in children and adolescents (e.g., Compton et al., 2004; Higa-McMillan et al., 2016; Walkup et al., 2008). Exposure exercises—widely accepted to be among the most essential ingredients of effective CBT for anxious youth (Kendall et al., 2005)—have children develop a hierarchy of situations and objects that cause them fear, as they systematically confront these feared experiences in a graduated fashion. Other key CBT ingredients for child anxiety include: psychoeducation about the harmless and normative nature of anxiety, self-monitoring (child or parent observes and keeps logs of their anxious patterns, behaviors, and thoughts), contingency management (child is rewarded and reinforced for brave behaviors, rewards are removed for behavioral avoidance), problem solving (child learns to identify problems and generate, select, and evaluate solutions), and thought challenging/cognitive restructuring (i.e., child learns to identify and modify anxious “self-talk”). Although relaxation training was once considered to be an important element of anxiety treatment, it is now considered less essential and potentially counterproductive, and is rarely included in modern CBTs for youth anxiety (Ehrenreich-May et al., 2016).

Despite advances in the identification of efficacious treatment practices for child and adolescent anxiety, significant barriers prevent those in need from accessing supported care. Indeed, epidemiological data show that rates of treatment among those with mental disorders is low, with less than half of affected individuals seeking any type of mental health treatment in a 12-month period (Wang et al., 2005). Treatment rates are lowest among vulnerable and traditionally underserved groups (e.g., economically disadvantaged, rural, racial/ethnic minorities, elderly, those lacking insurance; Wang et al., 2005). Moreover, when traditional clinic-based services are accessed, dropout rates are high (Wierzbicki & Pekarik, 1993). Several patient-level barriers have been identified, including attitudinal barriers (e.g., low perceived need and stigma; Mojtabai et al., 2011), financial limitations (Mojtabai, 2005) and structural barriers (e.g., geographically underserved regions; scheduling difficulties; transportation obstacles; Sareen et al., 2007). Organization-level and systemic barriers to traditional clinic-based services have also been identified, including mental health workforce shortages (Thomas, Ellis, Konrad, Holzer, & Morrissey, 2009) and English language proficiency (Derose & Baker, 2000). Moreover, individuals experiencing psychological distress perceive greater barriers to treatment than their non-impaired counterparts (Mohr et

al., 2010). Thus, the obstacles to providing evidence-based mental health treatment to those in need are highly entrenched in the American healthcare system and individual attitudes. Overcoming such barriers to quality mental healthcare will require a paradigm shift in the manner in which treatments are delivered (Comer & Barlow, 2014; Kazdin & Blase, 2011).

Over the last two decades, there has been increasing enthusiasm about the potential for leveraging technology to better meet population-level mental healthcare needs (Chou, Bry, & Comer, in press; Comer & Barlow, 2014; Kazdin & Blase, 2011). For example, technology-based or -assisted mental health interventions hold promise to provide treatment at a lower cost (Muñoz, 2010; Washington State Institute for Public Policy, 2015), though more research is needed to demonstrate cost-effectiveness at a systems-level (Schweitzer & Synowiec, 2012). Technology also affords the potential to overcome geographical obstacles and expand access to care to more individuals, including children and adolescents in geographically remote areas (e.g., Bunnell, Davidson, Dewey, Price, & Ruggiero, 2016; Comer & Barlow, 2014; Hilty, Cobb, Neufeld, Bourgeois, & Yellowlees, 2008; Price, Yuen, Davidson, Hubel, & Ruggiero, 2015). With about 75% of Americans accessing healthcare information online (Pew Research Center, 2015), the feasibility and acceptability of technology-based treatments appears to be on the rise. Moreover, recent randomized controlled trials have supported the initial efficacy of technology-enhanced interventions in improving children's mental health outcomes (e.g., Hedman et al., 2014; Jones et al., 2014; March, Spence, & Donovan, 2009; Spence, Holmes, March, & Lipp, 2006).

The platforms of behavioral intervention technologies (BITs) have increasingly shifted towards applications addressing healthcare needs via a range of mobile communication devices -referenced broadly as mHealth applications. While mHealth platforms range across a number of consumer products (e.g., smartphones, tablets, wearable sensors), the present evaluation focuses specifically on those made available for smartphones; Jones et al., 2015). Given the increasing prevalence and usage rates of smartphones, in particular, across a wide range of demographics (e.g., youth, racial/ethnic minorities, those dwelling in rural communities; Pew Research Center, 2017), smartphone applications are being developed as a novel method of extending access and delivering mental health treatment to traditionally underserved groups (Anton et al., 2016). Preliminary studies point to evidence for the acceptability of using smartphones to monitor mental health (Torous, Friedman, & Keshavan, 2014) as well as the feasibility and efficacy of delivering interventions on smartphones (Donker et al., 2013; Jones et al., 2014), however this body of literature is inchoate, precluding firm conclusions.

Innovative research groups are increasingly drawing on the expanding technological capabilities and functionalities of smartphone platforms which afford unique opportunities for patient monitoring and treatment. For example, a phone's sensor data, (i.e., its use of the innate GPS, accelerometer, and/or microphone) can allow for passive data collection on user sleep patterns, heart rate, social context, physical location, mood and stress levels (Mohr, Zhang, & Schueller, 2017), each providing clinical information that can relate to a user's physiological anxiety symptoms and the environmental factors producing such. Furthermore, smartphone platforms provide features that allow for ecological momentary assessment, "just-in-time" intervention, and the delivery of interactive, tailored treatment content aligned

with the precision medicine movement (Schueller, Muñoz, & Mohr, 2013) in ways face-to-face treatment may not.

The unique opportunities brought about by smartphones and related mobile communication technologies have not gone unnoticed by the private sector, evidenced by the proliferation of industry-funded mental health apps available on the consumer market place. As of January 2014, there were roughly 2,000 mobile apps marketed for anxiety alone that were available to consumers (Chan, Torous, Hinton, & Yellowlees, 2014) and a national US survey showed that more than half of Americans had downloaded at least one health-related app (Krebs & Duncan, 2015). Despite growing mHealth development and research within academic settings, research-to-practice gaps and poor dissemination of science-based healthcare innovations to the general public persist (Westfall, Mold, & Fagnan, 2007). Amidst rapid expansion of industry-sponsored mHealth apps marketed for consumers, it is not clear whether supported mHealth apps developed in academic settings are actually reaching consumers, and whether mHealth apps that are readily available on the consumer marketplace are grounded in evidence-based principles.

Despite the high prevalence and burdens of child and adolescent anxiety disorders, and despite advances in academic settings in the development and examination of mobile apps for youth anxiety, to date no studies have evaluated the scope and quality of mobile apps actually dominating the consumer marketplace for child or adolescent anxiety. The present study entailed a systematic content analysis of readily searchable apps on leading consumer marketplaces for mobile communication technologies. Given concerns about the quality of mobile apps targeting other mental health problems (e.g., depression, Shen et al., 2015; eating disorders, Juarascio, Manasse, Goldstein, Forman, & Butryn, 2015), it was hypothesized that the majority of mobile apps marketed to consumers for youth anxiety would not include the critical evidence-based components supported in research trials for treating youth anxiety (e.g., exposures, psychoeducation about anxiety, self-monitoring, contingency management, development of fear hierarchies, problem solving, and thought challenging). To further examine the research-practice gap, apps were also evaluated on the extent to which they incorporated advanced technological components and functionalities highlighted in the academic mHealth literature (e.g., ecological momentary assessment, data collection through sensors). Lastly, comparisons were made between the content and functionalities of free apps in the consumer marketplace to the content and functionalities of apps that cost money to explore whether financial considerations might be associated with the quality of apps for child and adolescent anxiety.

Methods

App Search Criteria and Selection Procedures

Screening and assessment of apps for study inclusion was guided by a systematic review process and restricted to the two most widely used marketplaces for mobile apps: Android's Google Play store and Apple's iOS App store (Boulos, Wheeler, Taveres & Jones, 2011). Search terms were identified for anxiety-related apps and included two technical terms (i.e., *anxiety*, *phobia*) as well as two common synonyms and layperson alternatives (i.e., *fear*, *stress*) in effort to identify consumer-driven products that take into account varying levels of

mental health literacy. These four anxiety search terms were crossed with a second set of four search terms to restrict results to apps specific to youth problems (i.e., *child*, *kid*, *teen*, and *adolescent*). Combining each of the four search terms for anxiety with each of the four search terms for youth resulted in 16 unique searches in each of the two app marketplaces, for a total of 32 searches.

Given research suggesting that only a small number of users view apps past the first 10 ranked apps in their search query, and most downloaded apps are listed within the first 5 ranked apps per those search terms (Dogruel, Joeckel, & Bowman, 2015), not all apps that were generated in each search were evaluated. As a conservative approximation of potential consumer search patterns, the study team included up to the top 30 results from each of the 32 unique searches.

The Google Play store and Apple App store were inventoried using the aforementioned search terms during a single week in February, 2016 resulting in the identification of 755 total apps, as some search terms yielded fewer than 30 results. 182 of these apps were identified as duplicates (either on the basis of appearing in both the Android and Apple marketplaces, or appearing in the results of multiple search term combinations) and excluded. The remaining 573 unique mobile apps were further scrutinized for study inclusion. Apps meeting the following inclusion criteria were retained for analysis: (1) marketed for the treatment or management of anxiety-related symptoms, (2) intended for use by children, teens, or their parents (i.e., apps were not specifically listed for adult use only), (3) available to the public for download, (4) available in English, and (5) evidenced stability in the marketplace by remaining available throughout the entirety of the 6 month coding window.

Two study authors (LB and TC) used the information provided in the apps' titles, app store descriptions, and available screenshots to identify those apps meeting the above inclusion criteria. The most common reason for exclusion were apps that, despite appearing in search results for anxiety-related apps, did not make any mention of treating or managing anxiety-related symptoms in their description pages. Most of these apps were games or other multimedia content marketed toward youth. An ultimate sample of 121 apps met inclusion criteria and was submitted to content analysis.

App Coding

A codebook was created to organize content analysis and optimize intercoder reliability. Content analysis consisted of noting the presence or absence of all study codes except reading level, which was treated as a continuous variable. Reading level of each app was approximated by uploading the full text included in the app's description page into a Flesch-Kincaid grade level calculator. Other study codes included descriptive characteristics of the apps: (1) age category (the app rating that the app platform, not the developer, has assigned via the app's description page.), (2) price category (free versus for-purchase) (3) confidentiality (the app offers the option of logging in via a set password and/or the app directly states its security, privacy, or data storage policy), and (4) risk-management (the app includes language regarding the management of suicidal ideation, mental health emergencies, and/or indicates the app is not intended to replace a therapist). For each app,

coders also recorded the presence versus absence of three specific mobile app functionality components: (1) sensors (data is imported to the app via sensors innate to the smartphone that capture motion, orientation, or environment), (2) interactivity (the app's content is individualized and influenced by user behavior, input, or context, and/or the app provides customizable options to users based on preference), and (3) ecological momentary assessment (assessment and/or intervention, in real time, of the user's mood, thoughts, behaviors or distress level).

Consensus guidelines on research-supported practices for youth anxiety (Chorpita & Daleiden, 2009; Higa-McMillan et al., 2016; Silverman, Pina & Viswesvaran, 2008) were consulted, and a panel of three doctoral-level youth anxiety experts provided additional input to identify the key evidence-based practice components in the treatment of child anxiety. For each app, coders recorded the presence or absence of six identified evidence-based treatment components: (1) Psychoeducation, (2) Self-monitoring, (3) Cognitions and Thought Challenging, (4) Problem Solving, (5) Contingency Management, and (6) Exposures. See Figure 1 for definitions of how these components were operationalized for study coders. In addition, given historical recommendations for relaxation training in the treatment of youth anxiety, despite waning enthusiasm for the practice in modern CBTs for youth anxiety, coders also assessed apps for Relaxation Training, see Figure 1.

Three coders (LB, TC, and EM) were trained to reliability on several rounds of sample mental health apps. Coders had to achieve an inter-rater reliability criterion of $k=0.80$ on a series of 8 independently coded apps before initiating coding on the study apps. The final round of independent practice coding revealed high concordance and high inter-rater reliability $k=0.93$.

The 121 study apps were downloaded from their respective app stores and each was assessed and coded by at least one study coder. To ensure inter-rater reliability, 20% of the overall app sample was independently double-coded by two reviewers. Inter-rater reliability was calculated overall, as well as on individual codes. Overall Kappa reliability coefficients ranged from $k=0.71$ – 1.00 on individual codes and an overall reliability of $k=0.94$ indicating strong reliability (Fleiss, 1971).

Data analysis

Cohen's kappa values and descriptive statistics were calculated using SPSS version 23. Chi square tests were computed to make comparisons between free and for-purchase apps on all categorical variables. T-tests measured differences between free and for-purchase apps for all continuous variables.

Results

Sample characteristics

Table 1 presents characteristics of the sampled youth anxiety apps available on the consumer marketplace. Over three-quarters of the sample were Android apps found in the Google Play Store. The majority of sampled apps were available free of cost. Among apps that were not available for free, prices ranged from \$0.99–\$6.99 ($M= \$1.21$, $SD=1.74$). The majority of

apps in the sample had a formal age classification designated through the app store as being appropriate for either “Everyone” (Google Play Store) or those ages “4+” (Apple iTunes Store). The mean Flesch-Kincaid Grade Level score of the overall sample indicated that the content on study apps were written, on average, at a 9th grade reading level. The mean Flesch-Kincaid reading level of apps specifically categorized as “Everyone” or age “4+” indicated that content on these apps’ description pages was also written at a 9th grade reading level. Lastly, features to maintain user safety were scant within the sample. Specifically, features related to user confidentiality (e.g., passwords, statements about data security) were found in less than 5% of apps in the sample. Statements regarding acute risk, crisis or suicidality aimed at directing users to more appropriate risk management outlets were more frequent within the sample, but found in only 1 out of every 6 apps.

Functionality components

Advanced functionalities often included or touted in the academic literature on the potential of mHealth were rare among sampled apps for child anxiety on the marketplace (see Table 2). No apps gathered data passively through sensors and less than 5% of the sampled apps used ecological momentary assessment to evaluate or “ping” user mood, emotional or behavioral states in real time. Lastly, apps that allowed users to customize content to their preferences or those containing interactive, logic-driven content reacting to user input were similarly rare.

Evidence-based treatment components

Half of the sampled apps for child anxiety on the marketplace included any evidence-based treatment component (see Table 3), and 23% of sampled apps contained two or more evidence-based components. The most common evidence-based treatment component found across sampled apps on the marketplace was “exposure” which was found in a fifth of sampled apps. Similarly, roughly one-fifth of sampled apps on the marketplace contained mention of cognitive biases associated with anxiety or had instruction in thought challenging or cognitive restructuring, and nearly one-fifth of the sampled apps referenced self-monitoring, reflection, or tracking of one’s thoughts, emotions or behaviors. General psychoeducational information related to anxiety, its definition and symptoms, and how it is maintained or treated was scant among sampled apps, with only 1 in every 6 apps referencing such information. Mention of rewards or positive reinforcement for use of the app or brave/approach behavior toward anxiety-related situations was present in roughly 1 out of 10 apps, and problem-solving content was even more rare.

The majority of sampled apps marketed for youth anxiety that lacked any evidence-based treatment components were largely distraction tools, such as games (21%), coloring activities (9%), or other audio or visual distraction activities (9%). Roughly half of all study apps (53%) included relaxation exercises (e.g., breathing exercises, guided imagery, progressive muscle relaxation) which was once considered to be an important element of anxiety treatment, but is now considered less essential and potentially counter-productive, and thus rarely included in modern CBTs for youth anxiety.

Cost-related differences in evidence-based content

Table 3 also includes data on the presence of evidence-based treatment components, broken down by app cost (i.e., free versus for-purchase). Among specific evidence-based components, content related to cognitions and thought challenging was significantly more common among apps costing money than among free apps.

Discussion

Despite increased scholarly attention to the potential of leveraging smartphones to extend the reach of evidence-based treatments (e.g., Chou, Bry, & Comer, in press; Chou, Bry, Comer, 2017; Donker et al., 2013; Jones et al., 2015; Whiteside, 2016), and despite considerable industry activity in the development of smartphone apps for youth anxiety, this is the first investigation to systematically assess the overall quality of readily searchable smartphone apps for youth anxiety on leading consumer marketplaces. Of great concern, evidence-based components for the treatment of youth anxiety were quite scant among sampled apps on the consumer marketplace. The sampling strategy yielded very few standalone, comprehensive treatment or anxiety-management products. Although roughly half of the sample had at least one evidence-based treatment component, only a quarter of apps incorporated more than one evidence-based treatment component. Given that consensus treatment guidelines (e.g., Higa-McMillan et al., 2016) emphasize the need for a multi-component approach to treating youth anxiety (e.g., simultaneously including psychoeducation, thought challenging, contingency management, and exposure exercises into a course of treatment), there is a clear need to increase the development and accessibility of more comprehensive self-management apps that leverage multiple evidence-based treatment strategies. Indeed, without any formal body assessing and recommending self-management apps to consumers (FDA, 2015; Huckvale et al., 2015), the present findings suggest the possibility for consumers to encounter spurious or ill-equipped treatment apps for youth anxiety is high. Encouragingly, at the time of this report, the American Psychiatric Association and the United Kingdom's National Health Service in partnership with their National Information Board have both set out to endorse a range of self-management apps across mental health disorders to better guide consumers towards quality digital treatment options (APA Smartphone App Evaluation Task Force, 2016; National Information Board, 2015).

Evidence-based treatment of anxiety is generally regarded as a multicomponent procedure consisting largely of the content areas upon which apps were assessed (Chorpita & Daleiden, 2009). In addition to improving the flow of consumers toward quality comprehensive self-management apps, consumers may also benefit from using a single quality app dedicated to one practice element (e.g., thought restructuring) or a group of singularly focused treatment apps (i.e., pairing an app with exposure-based content with one geared toward thought restructuring). This more modular approach may better meet unique patient needs and symptom profiles, similar to in-clinic modular treatment approaches (Chorpita, Taylor, Francis, Moffitt, & Austin, 2004). Such a modular approach may also be more feasible to implement, as comprehensive apps incorporating a range of evidence-based features are highly complex and expensive for researchers and programmers to create and maintain

(Watts et al., 2013). Similarly, usability research suggests that most individuals are accustomed to using mobile phone apps in short bursts, and comprehensive, content-heavy mHealth apps may not align with end-user habits (Vaish, Wyingarden, Chen, Cheung, & Bernstein, 2014). Recent findings from a field trial piloting a modular mHealth approach for adults consisting of a suite of 14 distinct mental health apps coordinated by a central app “hub” showed favorable reductions in depressive and anxious symptomatology (Mohr et al., 2017) and favorable engagement (Lattie et al., 2016). Future research examining modular mHealth approaches for youth problems is needed to inform the extent to which single, comprehensive treatment apps versus suites of modular, individual practice element apps best promote user engagement and symptom reduction.

Moreover, endorsements for quality treatment apps focused on a single practice element may additionally benefit clinicians and patients already accessing treatment. Apps can offer innovative and user-friendly representations of traditional in-clinic concepts and out-of-session homework tasks such as mood and thought tracking. These apps may be useful to clinicians who recommend them as adjuncts to in-clinic treatment and may increase out-of-session homework compliance and overall engagement in treatment (see Jones et al., 2015). Relatedly, it is important to focus on within-app features that can improve engagement to mHealth interventions. Recent work on practice elements related to engagement in traditional child and adolescent treatments shows five prominent elements: assessment, psychoeducation, accessibility, attention to barriers to care, and goal setting (Becker, Boustani, Gellatly, & Chorpita, 2017). Using these as a guide, the present sample of apps would yield poor results on assessment, psychoeducation and goal setting, although given the mobile platform and rising rates of access to smartphones, this sample might score well on the accessibility and attention to barrier to care. Future work examining engagement factors in mHealth interventions is needed to fully consider the viability of mobile phones as a treatment platform. Further, research focusing on whether engagement-promoting factors differ across mHealth and more traditional face-to-face treatment delivery formats is needed to inform mHealth adherence and the extent to which mHealth platforms may ultimately increase access to care. For example, researchers focusing specifically on self-administered eHealth and mHealth engagement have noted high rates of attrition from these interventions (Christensen, Griffiths, & Farrer, 2009). However, using the model of “supportive accountability,” or pairing a treatment app or website with a human coach, researchers have found that just 10 minutes per week of coaching on engagement to the intervention with no other delivery of therapeutic content by the coach can significantly reduce attrition and improve mental health outcomes (Mohr, Cuijpers, & Lehman, 2013). mHealth apps available to consumers are beginning to incorporate human support strategies (e.g., Joyable, Coach.me), though none of the apps in this sample employed a human coaching model. Future research on how a human coaching model, or supportive accountability, relates to children and adolescents or families utilizing mHealth interventions will be important for considering engagement to these treatment models.

The present analysis found that less than 5% of the sampled apps marketed for youth anxiety addressed confidentiality. Research examining user attitudes and perceptions toward mHealth data security and patient privacy shows that patients are indeed concerned about the storage of personal health-related data in digital spaces and potential secondary use of such

data (Atienza et al., 2015). With only 4% of sampled apps containing a password protection or a data security notice, the majority of apps for youth anxiety may go against consumer comfort and preferences. Despite recent proliferation of apps available to consumers on public platforms, these apps may be met with consumer distrust and concerns over privacy.

Scholarly attention has frequently touted the great potential for mHealth platforms to leverage advanced mobile features and innovations to broaden intervention opportunities. One such area of interest relates to the measurement and monitoring of physiological indices of anxiety (e.g., arousal, heart rate, sleep patterns). The importance of *in situ* data for improving clinical assessment has been emphasized (Aldao & De los Reyes, 2015; Davis, May & Whiting, 2011; Silverman & Ollendick, 2005), and smartphones offer the ability to capture *in situ* data via sensors and ecological momentary assessment and integrate this information into the intervention itself to provide “just-in-time,” “in-the-moment” treatment content to users. Indeed, ecological momentary interventions for anxiety are gaining empirical support and scholarly attention (Schueller, Aguilera & Mohr, 2017). Yet, the present findings suggest that the vast majority of readily accessible smartphone apps for youth anxiety on the consumer marketplace lag behind scholarly enthusiasm in this area. Research focusing on EMA and sensors is a burgeoning area although to date, the majority of studies relating these to mental health outcomes have utilized only small samples (Mohr et al., 2017b). However, with continued advances, and as “wearable” devices and “tracking” personal data gain traction in the consumer market, a key future direction will be integrating objective sensor data and evidence-based assessment of physiological anxiety responses with interventions that are both accessible to consumers and make use of these data through actionable intervention.

Moreover, apps incorporating such advanced functionalities (often developed in academia) do not appear to be meaningfully penetrating the consumer marketplace. Despite opportunities for smartphone apps to bridge gaps between research and practice that have been observed with regard to traditional clinic-based care, researchers must be cautious about replicating a similar research-to-practice gap in the arena of mHealth. Traditionally, research shows an 18-year gap from the point of intervention development to widespread dissemination (Westfall et al., 2007). Technology has the potential to serve as an agile platform through which supported interventions may be more quickly disseminated and through which larger proportions of individuals in need of care may access quality care (Kazdin & Blasé, 2011). However, the present study suggests that currently, mHealth interventions developed in academic settings for youth anxiety are not yet being disseminated or made readily accessible to consumers. The findings from this report underscore a need for strategies that help researchers better break into the consumer marketplace to increase the availability of evidence-based mHealth interventions. Without such efforts, the field of mHealth is poised to replicate the well-documented research-to-practice gap associated with traditional care models (Weisz, Jensen-Doss, & Hawley, 2006).

The present findings also summon questions related to a replication of other known barriers to treatment. For example, significant differences were found between for-purchase apps and free apps in their incorporation of cognitive restructuring and thought challenging. Often, financial considerations can regrettably impact the quality of care received in traditional

office-based care, but technology may offer needed opportunities to balance the accessibility of evidence-based treatment. As the field of mHealth continues to evolve, caution must be taken to avoid perpetuating disparities in the quality of available services.

Limitations and future directions

Several study limitations warrant comment. First, although the present methodology attempted to replicate common consumer search strategies to identify youth anxiety apps, the present findings may not generalize to apps identified via other search strategies. However, little is presently known about the precise search patterns of consumers seeking to identify youth anxiety apps. For example, the present use of the search term “stress” as a hypothesized layperson synonym for “anxiety” may have influenced the search results. Many apps meeting selection criteria encouraged user download of non-evidence-based distraction tools like coloring books and games through statements that claimed these activities could decrease user stress. It is possible that restricting study search terms to just the more clinical and technical term “anxiety” may have yielded a sample with more favorable incorporation of evidence-based treatment components. Further work engaging consumers in generating search terms and examining the apps naturally selected by consumers may provide a more generalizable view of digital consumption.

Importantly, some high quality treatment apps did not make it into the present analysis based on this consumer-based search strategy. For example, the app SmartCAT (Pramana, Parmanto, Kendall, & Silk, 2014), an mHealth platform delivering CBT to children with anxiety, is an intervention developed in academia that incorporates EMA, a therapist portal and monitoring system, and all 7 evidence-based treatment components included for content analysis in the present study. However, at the time of the study’s app search and selection, and at the time of this report, the SmartCAT app is still not included in the top 30 search results of any of the 16 search terms used, despite its presence on the Google Play Store. Little is known about how search results are generated within app stores (e.g., what determines an app’s position as third in a search, versus thirtieth in that same search) and whether quality apps would have appeared using the set of search terms if apps had been culled beyond the top 30. Big data mining of app marketplaces could yield important information related to both consumer search patterns and search result rankings which could then inform consumer health literacy as well as researcher efforts to make quality, evidence-based interventions more accessible to consumers. Unfortunately, this data is privately owned through the Google and Apple corporations and would require specific permissions and access in order to be utilized for these purposes. Ultimately, it is important to keep in mind the scope of this current analysis as a consumer driven framework. Thus, these are the apps that appear to consumers who may be searching for self-management apps using common search terms, and these are the apps marketing themselves toward symptom management, regardless of the actual scope of content therein.

Second, the present focus on evidence-based treatment components predominantly emphasized cognitive-behavioral strategies. While CBT is considered the current gold-standard psychosocial intervention for youth anxiety (Walkup et al., 2008) and relevance mapping of randomized-controlled trials for youth anxiety formed the foundation of

treatment component focus, it is possible that this lens failed to capture other potentially useful intervention methods. Indeed, some have cautioned developers away from attempting to directly mimic in-clinic sessions and tools in behavioral intervention technologies given limitations associated with traditional face-to-face treatments as well as the potential to restrict design, innovation and creativity (Schueller et al., 2013).

Third, the present findings indicate that the most readily accessible apps that are marketed for youth anxiety are not strongly grounded in evidence-based treatment content. That said, formal investigations have not been conducted testing the efficacy of leading consumer apps on the marketplace. Despite the absence of evidence-based treatment components, it is nonetheless possible that sampled apps are effective and include other active elements. Randomized evaluations formally examining the effectiveness of leading consumer products for reducing youth anxiety would complement the present analysis and help determine the state of readiness for private-sector mHealth products to meet consumer mental health needs.

Further, this analysis represents a snapshot of accessible consumer-marketed anxiety apps from 2016, and it is possible that conducting the same study at a different time could yield different results. To partially account for potential fluctuations on the consumer marketplace, apps were only included for content review if they demonstrated stable accessibility by maintaining their presence on the marketplace across a 6-month study window. Relative stability of the youth anxiety app marketplaces was observed, with over 90% of the initially identified apps still available on the marketplace 6 months later.

Finally, given considerable variability in the number of screens and functionalities across apps, we standardly selected the app description pages (which all apps include) to assess app reading level. Importantly, the reading level of an app's description page may not be representative of the reading level of the actual app. That said, in this consumer-focused review, a description page may act as a "gatekeeper" to the actual app itself, with users judging app content based on what is marketed and how it is marketed in the description page. Reading level of this content, therefore, may impact the extent to which apps are eventually downloaded by users and ultimately their accessibility to consumers.

Conclusion

Despite limitations, the present study adds to a growing body of literature indicating that relatively little evidence-based treatment content is currently included in the majority of consumer-marketed mental health apps for a range of clinical targets (Shen et al., 2015; Juarascio et al., 2015). Given the high prevalence, early onset, stability and impairment associated with youth anxiety disorders, and given that today's children, teens, and families are more digitally connected than any previous generation (Pew, 2015), self-management of anxiety symptoms through mobile platforms may represent a developmentally appropriate treatment opportunity with significant public health potential. However, the present findings raise concerns about the quality of the majority of accessible smartphone apps marketed for youth anxiety. The present findings also highlight how, at present, smartphone apps that are most readily available to consumers contain relatively simplistic functionality and do not yet incorporate the more advanced data collection and intervention strategies touted in the mHealth literature. The present examination also shows that despite the existence of higher

quality apps developed and evaluated in research settings and in the private sector, such comprehensive self-management options that incorporate evidence-based treatment components are not highly visible to consumers and therefore will expectedly have limited reach. Future mHealth efforts would do well to explore strategies for researchers to better break into the consumer marketplace to increase the visibility and therefore accessibility of quality mHealth interventions.

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Highlights

- We analyzed the quality and scope of consumer-marketed apps for youth anxiety
- We found that evidence-based content within a systematic sample of apps was scant
- Features that engage advanced functionalities of smartphones were rarely present
- Findings underscore the need to better disseminate quality child anxiety apps

<p>Psychoeducation <i>Defined as the presence of any of the following:</i> Defines Anxiety Normalizes/ Adaptive in nature (e.g., fight of flight response) Provides prevalence rates Describes Cycle of Reinforcement Describes symptoms: Thoughts, Feelings, Behaviors Describes impairment domains Describes comorbidities associated</p>
<p>Self-monitoring <i>Defined as the presence of any of the following:</i> Self-evaluation of mood Self-evaluation of thoughts Self-evaluation of behaviors</p>
<p>Cognitions and Thought Challenging <i>Defined as the presence of any of the following:</i> Lists thought traps Negative self-talk Provides relevant examples of thought traps Describes automatic nature Looking for evidence (probability v possibility) So what if it happens? Alternate outcome/ "how else could it turn out?" "What would you tell a friend in the same situation?" Encourages user to generate neutral or positive, or more logical, self-statements</p>
<p>Problem Solving <i>Defined as the presence of any of the following:</i> Identifying the problem Identifying all possible solutions Evaluate each solution Try out the best solution Evaluate the outcome Creating a coping plan</p>
<p>Contingency Management <i>Defined as the presence of any of the following:</i> Internal app rewards (badges, levels, points) for effort and use Positive reinforcement description Reward planning and follow through Labeled praise Describes fading rewards over time</p>
<p>Exposures <i>Defined as the presence of any of the following:</i> Provides definition and rationale for exposures Provides example of appropriate gradation (starting small/ easy) Instructs user to form hierarchy Provides visualization of user's hierarchy Encourages approach, not avoidance Imaginal or In vivo</p>
<p>Relaxation Training <i>Defined as the presence of any of the following:</i> Somatic Responses to anxiety Prompts user to list/identify their anxious feelings Focus on Pleasant Stimuli/ Distraction Guided/ Structured Mindfulness Progressive Muscle Relaxation Breath Training</p>

Figure 1.
 Study definitions of evidenced-based treatment components within study apps

Table 1

Characteristics of sampled youth anxiety apps on the marketplace (N=121)

	N	%
Marketplace		
Google Play Store	83	68.6
iOS App Store	38	31.4
Cost		
Free	70	57.9
For Purchase	51	42.1
Designated Age Classification		
Everyone/Ages 4+ ^a	91	75.2
Not for everyone/Ages 4+ ^a	30	24.8
Confidentiality		
Yes	5	4.1
No	116	95.9
Risk Management		
Yes	18	14.9
No	102	85.1
	M	SD
Flesch-Kincaid Reading Grade Level	9.3	3.4

^aGoogle Play Store and iOS App Store have different age classification levels. The lowest age classification level on the Google Play Store is "Everyone," whereas the lowest age classification level on the iOS App Store is "Ages 4+".

Table 2

Prevalence of advanced functionalities across sampled youth anxiety apps on the marketplace (N=121)

	<u>N</u>	<u>%</u>
Individual Functionalities		
Sensors		
Yes	0	0.0
No	121	100.0
Interactive Content		
Yes	3	2.5
No	118	97.5
Ecological Momentary Assessment		
Yes	4	3.3
No	117	96.7
Any Advanced Functionalities		
Yes	5	4.1
No	116	95.9

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Table 3

Prevalence of evidence-based treatment components across sampled youth anxiety apps on the marketplace (N=121)

	Total sample	Cost				Significance test	
		Free		For-purchase			
		N	%	N	%		
Individual Evidence-Based Components							
Exposures							
Yes	26	21.5	16	13.2	10	8.3	$\chi^2(1, 121) = 0.19, p = 0.67$
No	95	78.5	54	44.6	41	33.9	
Cognitive Restructuring/Thought							
Challenging							
Yes	25	20.7	10	8.3	15	12.4	$\chi^2(1, 121) = 4.12, p = 0.04$
No	96	79.3	60	49.6	36	29.8	
Self-Monitoring							
Yes	24	19.8	11	9.1	13	10.7	$\chi^2(1, 121) = 1.77, p = 0.18$
No	97	80.2	59	48.8	38	31.4	
Psychoeducation							
Yes	20	16.5	9	7.4	11	9.1	$\chi^2(1, 121) = 1.62, p = 0.20$
No	101	83.5	61	50.4	40	33.1	
Contingency Management							
Yes	14	11.6	10	8.3	4	3.3	$p = 0.39$, Fisher's Exact Test
No	107	88.4	60	49.6	47	38.8	
Problem Solving							
Yes	6	5.0	2	1.7	4	3.3	$p = 0.24$, Fisher's Exact Test
No	115	95.0	68	56.2	47	38.8	
Any Evidence-Based Component(s)							
Yes	60	49.6	32	26.4	28	23.1	$\chi^2(1, 121) = 1.00, p = .32$
No	61	50.4	38	31.4	23	19.0	