Self-monitoring practices, attitudes, and needs of individuals with bipolar disorder: implications for the design of technologies to manage mental health

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ABSTRACT

Objective To understand self-monitoring strategies used independently of clinical treatment by individuals with bipolar disorder (BD), in order to recommend technology design principles to support mental health management.

Materials and Methods Participants with BD ($N = 552$) were recruited through the Depression and Bipolar Support Alliance, the International Bipolar Foundation, and WeSearchTogether.org to complete a survey of closed- and open-ended questions. In this study, we focus on descriptive results and qualitative analyses.

Results Individuals reported primarily self-monitoring items related to their bipolar disorder (mood, sleep, finances, exercise, and social interactions), with an increasing trend towards the use of digital tracking methods observed. Most participants reported having positive experiences with technology-based tracking because it enables self-reflection and agency regarding health management and also enhances lines of communication with treatment teams. Reported challenges stem from poor usability or difficulty interpreting self-tracked data.

Discussion Two major implications for technology-based self-monitoring emerged from our results. First, technologies can be designed to be more condition-oriented, intuitive, and proactive. Second, more automated forms of digital symptom tracking and intervention are desired, and our results suggest the feasibility of detecting and predicting emotional states from patterns of technology usage. However, we also uncovered tension points, namely that technology designed to support mental health can also be a disruptor.

Conclusion This study provides increased understanding of self-monitoring practices, attitudes, and needs of individuals with bipolar disorder. This knowledge bears implications for clinical researchers and practitioners seeking insight into how individuals independently self-manage their condition as well as for researchers designing monitoring technologies to support mental health management.

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BACKGROUND AND SIGNIFICANCE

Serious mental illness affects 9.6 million adults (∼4.1%) in the United States,[1] and the World Health Organization predicts that nearly 50% of US adults will develop at least one mental illness during their lifetime.[2] Bipolar disorder (BD) specifically has been recognized as one of the 10 most debilitating illnesses worldwide,[3] affecting approximately 5.7 million American adults in any given year, with 82.9% of these cases classified "severe."[4] For BD, functional and clinical outcomes are often poor,[5] 1 in 5 cases results in suicide,[6] and overall, the condition is associated with heavy personal and societal costs.[7]

BD is characterized by dramatic shifts in mood, energy, activity levels, and the ability to execute daily tasks.[8] An individual with BD experiences distinct "mood episodes." The manic mood state is associated with a very positive state of mind, high energy, and pronounced irritability. Symptoms of mania include racing thoughts, distractibility, impulsivity, extreme multitasking, and sleep loss. In contrast, depressive mood phases are characterized by inactivity, fatigue, as well as social withdrawal and isolation.[1] There are several subtypes of BD, including the following. In bipolar I disorder (BD1), manic or mixed episodes last at least 1 week and depressive episodes typically last at least 2 weeks. Bipolar II disorder (BD2) is slightly less extreme and includes patterns of hypomania and depression but no fully manic or mixed episodes, as occur in BD1. In bipolar disorder not otherwise specified (BD-NOS), BD symptoms do not meet the official diagnostic criteria of BD1 or BD2. Finally, cyclothymia is a mild form of BD in which periods of hypomania and moderate depression last for at least 2 years.[1]

Recent research has linked BD episodes to disturbances in circadian rhythms and lifestyle regularity, suggesting that treatments targeting the tracking and stabilization of behavioral, social, and sleep-wake routines may improve patients' outcomes.[9–11] The standard practice for tracking BD behaviors and symptoms involves paper-based diaries, such as the Social Rhythm Metric.[12] However, nonadherence to such methods is common, especially when concentration is compromised during manic or depressive episodes; in addition, the paper format hinders the synthesis of data into easily-digestible summaries.[13]

One promising alternative to paper-based diaries is technology-based health tracking, which is becoming increasingly ubiquitous through both wearable devices and mobile applications.[14] 7 in 10 US adults track a health indicator for themselves or a loved one,[15] and the National Council for Behavioral Health advocates for extending technology-based monitoring to mental health patients.[16] Initial research suggests that individuals with BD are receptive to such monitoring; for instance, studies have shown that BD patients preferred mobile- and computer-based tracking methods over traditional paper formats and perceived that these methods reduce stigma while affording more involvement in treatment.[17–19]

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OBJECTIVE

We seek to better understand how and why individuals with BD are self-monitoring their behaviors and symptoms in everyday life (i.e., away from clinical settings), with the ultimate goal of translating our findings about their health tracking practices, attitudes, and needs into guidelines for technology-based solutions. Specifically, we set out to:

1. Investigate how individuals with bipolar disorder monitor and manage their condition.
2. Assess individuals' experiences and attitudes regarding the tracking of mental health indicators, in terms of perceived benefits and limitations.
3. Probe our participants' outlooks on future tracking technologies – both user-driven tools that support manual recording as well as system-driven approaches for automatic tracking, feedback, and prediction.

MATERIALS AND METHODS

Instrument

We developed a survey that included a mix of multiple-choice, multiple-answer, Likert-style, and open-ended questions. Quantitative data from the closed-ended questions were analyzed descriptively. Responses to the open-ended questions were qualitatively analyzed using open coding,[20] with iterative derivation and refinement of codes guided by the data and with interpretation of commonly observed themes guided by extant literature. Specifically, three researchers independently developed a list of themes as they emerged from the data, next discussed these themes to enhance their original set of codes, then undertook a subsequent stage of analysis to code the remaining responses, and finally resolved disagreements in the complete coding. The survey items covered:

- **Health-management practices:** Any health indicators monitored, modalities used to track these indicators, whether the tracking data was shared with healthcare providers, and thoughts about tracking's impact on their health and BD.
- **Technology use's relation to BD:** Any variance in usage prior, during, or after a mood episode and any awareness of technology-based triggers or warning signs of relapse.
- **Demographic information**, including details of the bipolar disorder diagnosis and any mood episodes experienced.

We deployed our survey through the Depression and Bipolar Support Alliance (DBSA)'s website and Facebook page; the International Bipolar Foundation's monthly e-newsletter and Facebook and Twitter pages; and WeSearchTogether.org, a website that helps researchers recruit participants for studies related to mood disorders. No statistically significant differences were found in survey responses across these sources. Study recruitment was directed at any person who self-reported a confirmed diagnosis of bipolar disorder. Research indicates that those who report having a BD diagnosis almost always actually do.[21] Survey responses were anonymously collected, although 51% of the study participants provided an email address to enter an optional iPad drawing. Cornell University's Institutional Review Board approved all study procedures.

RESULTS

Participants

Figure 1 shows the demographic characteristics of our 552 respondents (interchangeably referred to as participants), who answered the survey between September 2013 and April 2015. Though research

generally suggests that gender differences in rates of bipolar disorder are minimal,[22] the fact that most of our respondents were female is not necessarily unexpected, given that women may be more at risk for bipolar disorder and experience more severe manifestations[22,23] or at least are more likely to seek help and receive diagnoses for mental health problems[24]. The distributions of BD subtypes in our study sample are representative of existing prevalence estimates,[25] except for the lower incidence of cyclothymia,[26] which, together with the high number of reported BD episodes, suggest that our respondents may have relatively severe BD presentations.[27]

Self-Monitoring Practices

We first explore the ways in which individuals currently monitor their general health and their bipolar disorder specifically, including whether they use technology to do so.

Indicators Tracked

Our survey respondents reported tracking a range of behaviors and health indicators but primarily tracking BD-related information (see Figure 2). Closed-ended survey questions specifically inquired about tracking mood, sleep, finances, exercise, and social interactions – indicators that are relevant to BD since mood is a core feature of the disease, stability in sleep-wake rhythms is critical to emotional regulation for BD,[28,29] excessive spending during manic episodes can cause financial repercussions,[30] exercise helps regulate mood and combat the weight gain commonly associated with depression and BD medications,[31,32] and social isolation is a known correlate of depression.[33,34]

According to an open-ended survey question about whether respondents tracked anything else and the method they used to do so, 43.9% of participants reported that they track various other items that are relevant to their condition, including medication, side effects, and doctor's appointments as well as personal triggers and manifestations of symptoms, such as caffeine and alcohol intake, pain levels, appetite, libido, suicidal ideation, and self-harm. One-fifth of the survey respondents also noted tracking items such as chores, pet care, leisure time, and recipes as a way to structure daily behaviors given that lifestyle regularity may improve BD management.[28,29,35–37]

Modalities of Tracking

According to separate open-ended survey questions about their methods for tracking mood, sleep, finances, exercise, and social interactions, participants who track those indicators reported using paper, technology-based methods, mental notes, and (less commonly) feedback from other people (see Figure 3).

The forms of paper-based tracking that participants mentioned using include journals, sticky notes, charts, and calendars. Some respondents print out templates found online, while others create individualized scales, in which, for instance, numbers correspond to self-defined mood states. Regarding technology-based tracking, Table 1 provides details and examples of all the methods that participants reported utilizing. Interestingly, survey respondents also mentioned self-monitoring using technology-based methods that are not purposely designed for self-tracking – e.g., reviewing chat or phone logs to track sociability.

Survey respondents also reported keeping track of health indicators in their heads, particularly for highly consistent routines or when they feel familiar enough with their condition to maintain an inner sense of emotional balance. Still, respondents reported turning to external tracking via paper or technology when they need extra support, for instance, when thoughts get "scrambled" or their mind feels too

Figure 1: Respondent demographic characteristics.
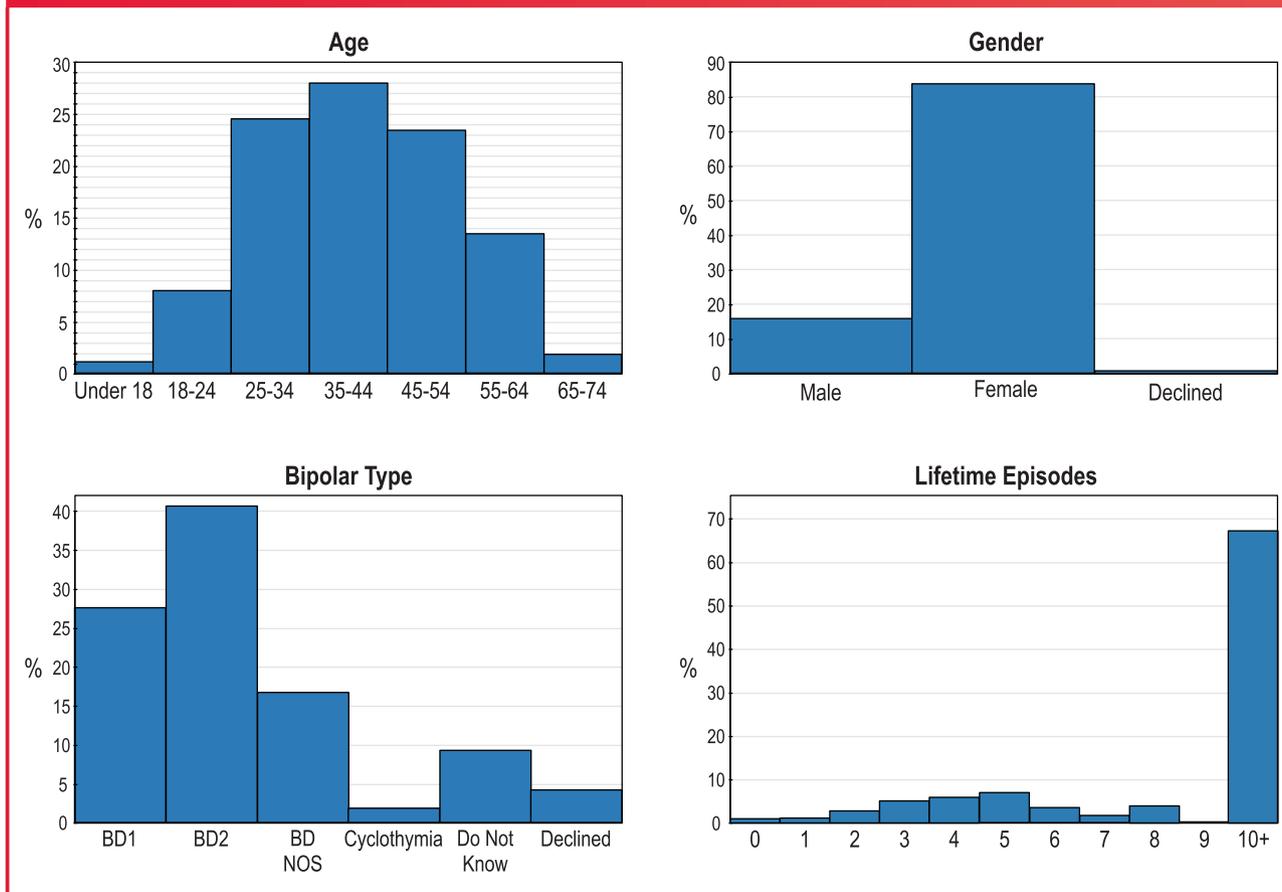
"full" – sensations that are especially common during BD episodes. Survey respondents also described using social feedback as another form of monitoring, for instance, by periodically reporting their mood to loved ones or by depending on trusted connections to act as a sort of "human sensor" who can notice the warning signs of a BD episode.

Survey respondents' approaches for tracking multiple indicators vary. Participants were divided between keeping separate journals or tools, each dedicated to chronicling a particular indicator, or tracking all items with a single chart or application. Sometimes, elaborate tracking setups are reported as necessary to accommodate such tracking habits in ways technologies do not currently support.

Finally, open-ended survey question responses suggest that an individual's tracking practices can shift over time and with the severity of the condition. One path is to initially use a simple chart or application to self-monitor a few condition-related indicators and gain insights into broad patterns of these indicators. Respondents expressed how this strategy provides a gentle introduction to self-monitoring. Then, as time goes on, the individual might adopt more applications or customized setups to track additional indicators, at a more fine-grained level and frequency, and across both symptomatic and stable periods. Finally, once individuals have been managing their BD for years, they describe gaining a sense of control that stems from better understanding their personal condition and how their routine affects it. They explain that it eventually becomes possible to rely on mental tracking and less on overt tracking strategies, which are used more as a fallback when something out of the ordinary happens or in times of severe emotional distress.

How Self-Monitoring Helps

Over 63% of study participants reported that tracking via any method has changed their overall approach to maintaining their health, 11% reported that it did not, and the remaining 26% were unsure of tracking's impact on their health. In the sections that follow, we explore the perceived benefits and challenges of tracking, along with opportunities for technology to support and overcome these positive and negative aspects.

Making Health Management Manageable

When asked to describe the ways that tracking has affected their approaches to maintaining health, a prominent theme the study participants touched upon was that tracking makes staying on top of their BD more manageable. For these respondents, health management can seem like a full time job that leaves little time for anything else, and tracking provides enough organization to "move past sheer maintenance and into the realm of improvement", as one participant put it.

Survey respondents reported that they are increasingly adopting technology-based tracking in place of paper methods since applications or websites can be used to chronicle behaviors or symptoms anytime and anywhere. Similarly, individuals who face financial or geographical hurdles to regularly visiting a therapist stated that ubiquitous tracking applications make it possible to manage their condition between therapy visits. Survey respondents – especially those with comorbid disorders, such as Attention Deficit Hyperactivity Disorder – noted that tracking would simply be "unsustainable" without the assistance of technology. Compared to the use of personal informatics

Figure 2: Percentages of respondents (*y* axis) who report tracking specified indicators (*x* axis).
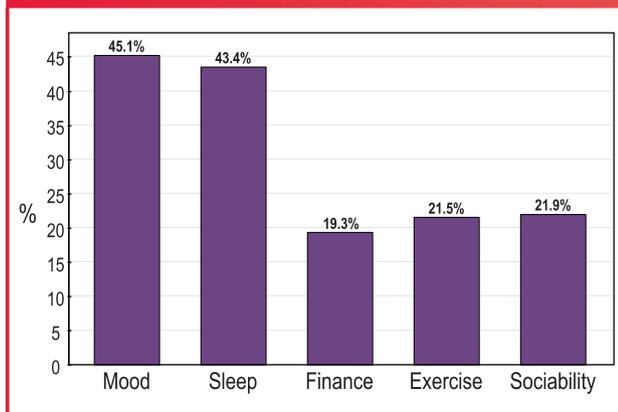
Figure 3: Percentages (*y* axis) of various methods (key) used to track specified indicator (*x* axis).
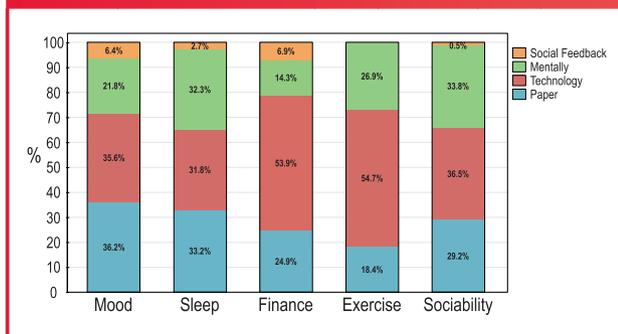
tools by the general population, it appears that such accessibility does not merely provide convenience for individuals with BD, but rather it is a lifeline and vital necessity.

Finally, beyond tracking itself, survey respondents described using technology to manage behavioral regularity, for instance, via alarms and alerts that help them adhere to consistent sleep-wake cycles.

Promoting Self Awareness, Reflection, and Empowerment
Another emergent theme from our results is that tracking supports self-reflection and facilitates the discovery of behavioral patterns and relationships between lifestyle, mood, and health – including the identification of personal symptom triggers such as caffeine, weather, or exposure to negative social media content. The survey respondents noted that tracking also helps them learn how affective episodes tend to manifest, which leads to a better understanding of their disorder and ways to manage it. A majority of respondents described this awareness as an opportunity to become proactive about their condition, helping them make adjustments to preempt mood episode triggers and maintain stability or at least avoid severe episodes. Survey respondents also stated that the feedback provided by tracking keeps them accountable to themselves and that they find visual forms of feedback particularly helpful for identifying personal behavioral and emotional patterns and motivating positive lifestyle choices.

The survey responses convey that participants' ability to take a more direct role in managing their own health helps empower them and

helps them develop a more internalized locus of control – perceptions of agency that they described as instrumental to recovery. Participants explained that the control afforded by tracking helps them keep calmer since it helps their lives feel more structured, manageable, and purposeful. Relatedly, participants stated that using tracking to externalize information – about their mood, for instance – facilitates emotional release. Additionally, respondents noted that self-monitoring helps them learn patterns of recovery for dealing with mood shifts. Gaining such insights then boosts participants' confidence regarding coping strategies and helps them be less hopeless and self-critical because it enables them to keep perspective and remain optimistic that hard moments will pass. Responses suggest that this dual sense of self-efficacy and self-compassion derived from tracking helps participants be kinder to themselves and make more nurturing and understanding decisions about their mental health. Participants also noted that this increased self-awareness is important when they are unable to cope with a mood episode – for instance, by helping them recognize when they need to reach out for help from others just prior to the onset of severe symptoms.

Supporting Interactions with Clinicians
About two-thirds of the survey respondents reported using self-tracking data during discussions with a healthcare professional, such as a doctor, psychiatrist, or therapist. When asked to provide details about these discussions, most of the respondents described these interactions as positive, namely because tracking provides a way to open and maintain lines of communication with their treatment team. Specifically, participants explained that self-tracked data helps them relay symptomatic patterns to their care team in a more aggregate manner than they could do on their own, and they also mentioned that the data enabled them to more accurately recount behaviors and events, especially if significant time had passed since a prior appointment. Participants stated that these data also provide a starting point for dialogue with their physician, help them broach specific issues or points of concern, give them defensible evidence for discussions about treatment efficacy or medication adjustments, and, overall, have made them more "active patients" who do not "simply fill prescriptions."

These respondents also explained that their doctors are receptive to tracking and the information it generates, help foster a consistent tracking habit, and may even require tracking to be reported to them. In the case of some respondents, their doctors introduced the notion of tracking in the first place, while other respondents initiated tracking independently but found their doctors to be open to receiving the information gleaned from self-tracking.

Challenges (and Opportunities) for BD Monitoring
Despite these benefits, survey responses also reveal that self-monitoring presents some challenges for participants, especially given the limitations of health tracking tools that are designed for general use. These difficulties also present opportunities to better meet the specific needs of individuals with BD through technology-based solutions, solutions that would be well-received – especially if they could replace medication – according to 80% of survey respondents, who feel that technology has the potential to help them manage their BD.

Tracking BD-Specific Indicators
According to survey responses about the ways technology could better support health management, the foremost desire is for tracking tools to

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Table 1: Types and Examples of Technology-Based Methods Utilized to Track Mood, Sleep, Finances, Exercise, and Social Interactions	
Indicator	Technology-based methods used to track indicator
Mood	Charting software, digital notebooks (e.g., Evernote, OneNote) and notepad applications, spreadsheets, smart phone or tablet applications (e.g., eMoods, iMoodJournal, Moodlytics), online mood trackers (e.g., the Depression and Bipolar Support Alliance's Wellness Tracker, MoodChart.org, MoodTracker.com)
Sleep	Computer programs, mobile applications (e.g., FitBit) and alarms, websites (e.g., Optimism)
Finances	Banking websites or mobile banking applications, digital spreadsheets, financial software
Exercise	Mobile applications or online counterparts (e.g., RunKeeper, MyFitnessPal), software that pairs with wearables designed to support health and fitness (e.g., FitBit, Jawbone)
Sociability	Websites or applications designed to log daily online and offline contact, digital calendars, manually reviewing chat or phone logs

be able to capture BD-relevant behaviors (e.g., mixed moods, well-known manic or depressive prodromes, and sleep) at a level of granularity that is sufficient for BD management (e.g., reporting multiple moods daily). Survey respondents proposed that digital versions of established paper instruments could be useful as technology-based tools; although some such tools do exist (e.g., ChronoRecord[18]), responses indicated a preference for more accessible tools that can be used at home and across different devices. Furthermore, respondents stated that more user-friendly tools are needed; complaints about existing tracking tools included cumbersome navigation, required sign-in, and other overly complex features that impede a quick logging session. Study participants stressed that such obstacles undermine their motivation to use technology-based tracking tools and lead them to revert to using paper-based methods or abandon tracking altogether.

Supporting Tracking Under Stress

Survey responses indicated that tracking tools' usability and the need for minimal effort are particularly salient design features during manic and depressive periods, when focus or energy is low and individuals are "just trying to keep [their heads] above water". A majority of respondents stressed that lowering such user burdens is key since failures to track can actually fuel symptoms by provoking increased feelings of anxiety, shame, or hopelessness. A related, important consideration is support for *in situ* logging during mood episodes, given that retrospectively capturing emotions and behaviors experienced during a mood episode is problematic. Respondents explain that low-effort tracking tool interfaces (e.g., that support speech input) would help them keep up with self-tracking even during the most difficult times. Participants also expressed a need for proactive reminders as part of tracking tools. Drawing a parallel to clinicians who tailor their assessment of a patient based on that individual's personal patterns, respondents recommended that tracking software could tailor what and how often to proactively track a user's data based on personalized models.

Automated Support and Analysis

The fact that one's ability to self-assess is compromised during mood episodes, particularly during hypomanic and manic episodes,[38] further motivates the pursuit of designs that externalize tracking by moving from user-driven to more technology-driven, automated approaches. Nearly all respondents conveyed high receptivity to the idea of more "intelligent" tracking systems that passively mine behaviors, automatically detect and predict affective changes, and report feedback to the user about his or her current state, the potential onset of symptoms, and appropriate coping strategies.

Such system-driven sensing seems feasible, given that nearly three-quarters of respondents described ways that their technology usage changes prior to and during mood episodes. These responses indicate that specific manifestations of behaviors vary by individual; but overall, we observed that mania and depression reflect themselves in antithetical ways: respondents explained compulsive, excessive, and inappropriate technology usage and sociability characterize mania, while apathetic use of technology, withdrawal from technology use, or full technological detachment characterize depression. Automatically tracking BD indicators also seems promising given that studies have found high correlations between phone usage patterns and self-reported mood and sleep patterns.[39] Systems such as MoodRhythm[13,40] and MONARCA[41] have attempted to utilize such sensing strategies to predict mood episodes and provide feedback to users.

However, our survey responses reveal that, in addition to signaling mood disturbances, technology usage can also unfortunately trigger them. Participants explained that exposure to disturbing content, online social distress, and excessive or late-night technology usage can all provoke emotional and behavioral instability.

Improving Clinical Interactions

Technology-based tracking is not formally supported by the majority of clinics, and, even among survey respondents who noted that tracking facilitates clinical interactions, better ways to share data with and communicate data to healthcare providers are desired. However, translating raw data into useful formats for clinicians is not easy.[42] Open-ended survey responses about how health tracking information gets used with healthcare professionals revealed that some problems are related to data transfer, such as when study participants could not print out reports of self-tracked data from desktop-based software or when treatment centers rejected data participants sent via email. Survey responses also described that interpreting data can be difficult for doctors, even when tracking tools produce aggregate data or graphs, because both the data and the tracking mechanism can be hard to make sense of outside of individual patients' own contexts. Overall, survey respondents who encountered problems related to clinicians not accepting or valuing their self-tracked data explained that such rejections leave them feeling resentful and makes their tracking efforts feel futile.

DISCUSSION

Guidelines for Technology-Based Mental Health Monitoring

Nearly two-thirds of our survey respondents reported that self-monitoring positively changed their overall approach to maintaining

their health by imparting behavioral, psychological, and social benefits. Most notably, tracking helped individuals self-enforce behavioral consistency; increased their self-awareness of BD patterns, triggers, and effective coping strategies; enabled the development of self-efficacy and self-compassion with respect to condition management; and facilitated conveying information about their moods and behaviors to caregivers. However, participants also reported problematic tracking experiences, which stem from frustrations with unintuitive, unreliable, or generic technology-based trackers not oriented around BD; difficulties remembering or adhering to tracking routines, especially during mood episodes; and challenges recognizing patterns from paper logs or interpreting aggregated digital reports, with or without their physicians. Based on these findings, we have derived a set of design implications, offered as guidelines in Table 2, for how technology could be designed to support positive aspects of self-monitoring and overcome the extant challenges.

Beyond tracking, study participants were asked how else they use technology to manage their BD. The themes that arose have also been documented by prior research on patient self-care practices[43,44] and confirm some fundamental health-management needs. Namely, respondents noted that using technology for information-seeking and to gain knowledge about their BD without direct doctor involvement is empowering and essential to effective management of their condition, as it helps them better accept and understand their illness. The same is true for the social support afforded by online social networks and BD forums, the latter of which in particular provide stigma-free connections with other individuals with bipolar disorder. Also mentioned as key to recovery is the ability to calm oneself or disrupt negative rumination via technology-mediated emotional and creative outlets (e.g., guided meditations, streaming music, and online poetry). Altogether, these findings suggest that tracking alone is not a single panacea to health management but that designers would do well to consider broader forms of technology-based mental health support, for instance, by delivering recommendations for peer forums to visit as a way to develop social connectivity or by mining and presenting a user's past online content to encourage positive reminiscence or gratitude practice – types of interventions that research has found to be more effective and appealing than medication.[45]

Tensions

We would also like to emphasize that, as we increasingly move towards technology-mediated and automated forms of health tracking, this study surfaces tensions that must be carefully navigated by the designers of such systems. First, although technology has the potential to augment the aforementioned benefits associated with self-monitoring and combat the aforementioned burdens, we observed in this study that the use of technology can have an agitating effect or even trigger emotional instability. Thus, we must carefully balance the tension between consistent technology-mediated tracking and the emotional and behavioral downward spiral to which overuse of such technology can lead. Similarly, the emotional and behavioral patterns that tracking tools reveal could themselves become triggers; for instance, knowing about a social "off week" might lead to useful behavioral changes or might fuel rumination on social inferiority, depending on how it is presented to the user and his or her status in terms of both mood and the ability to act on such feedback.

Additionally, technology that is capable of synthesizing large swaths of data and detecting patterns that are otherwise indiscernible may support self-reflection; and more automated forms of monitoring may promote adherence to tracking and, in turn, behavioral regularity

and emotional stability. However, given that the effort of tracking imparted substantial benefits to respondents' sense of self-efficacy, we must again be attentive to the tension between automation and manual tracking so as to not undermine the agency and mastery linked to more user-driven, deliberate, and mindful forms of tracking.

We advise other researchers to take a "do no harm" approach by carefully considering the promises and pitfalls of technology-based solutions, which have the potential to positively contribute to self-monitoring and mental health management in meaningful ways – as long as they are responsibly designed, developed, and deployed.

Future Work

Finally, we acknowledge the potential limitations of this study and outline room for future work. To begin, our research focuses on the needs of individuals with bipolar disorder with respect to monitoring daily behaviors and routines. Going forward, it is important to also better understand the corresponding needs of clinicians, determine the utility and feasibility of integrating technology-based monitoring tools into clinical activities, and realize how such tools may fundamentally change clinician-patient interactions. Similarly, there are additional stakeholders to consider such as family members or other caregivers, who may play an important role in monitoring in the context of mental health.

Additionally, our findings are based on survey responses, which may face well-known sampling and response biases, including sample composition, self-selection, social desirability, and acquiescence. In particular, recruiting through online channels may draw more technologically-savvy participants; also, recruiting through DBSA, the International Bipolar Foundation, and WeSearchTogether.org could select for people who tend to be more stable, higher functioning, and more proactive about managing their BD. Further, tracking practices are self-reported, as are perceived associations between technology use and mood disruptions, plus these perceptions might be influenced by a participant's mood at the time of surveying. Going forward, it would be desirable to more broadly administer expanded questionnaires or interviews to investigate the prevalence of characteristics, practices, and attitudes reported by this sample. It would also be worthwhile to analyze usage data in order to examine the differences between actual and perceived technology-mediated behaviors.

CONCLUSION

In this study, we assessed whether and how self-monitoring is regarded as useful by individuals with bipolar disorder, and we identified challenges to tracking or interpreting information. In the process, we shed light on individuals' broader attitudes towards self-monitoring and identified user needs that technology should meet. Deriving design implications from our findings, we presented guidelines for developing manual and passive monitoring tools that are applicable and usable in real-life settings and that can supplement a clinician's therapeutic efforts. Importantly, we emphasized that systems to manage mental health must be designed with care, so as to not heighten a user's instability in an attempt to preempt it. More generally, our findings underscore the need for designer responsibility in this context, given the vulnerability of the population being served and the complex relationship between technology usage and mental health.

CONTRIBUTORS

E.L.M., M.M., P.C., S.G., and E.F. contributed to the conception and design or analysis and interpretation of data. All authors (E.L.M., D.C., P.C., S.G., E.F.,

Table 2: Design Guidelines for Self-Monitoring Technologies for Managing Mental Health

Design implications	Needs addressed	Representative quotations from survey respondents
Deploy software across platforms, devices, and operating systems	Pervasive accessibility	"The easier it is to access the program the more likely I am to use it."
		"I like typing on my work computer but use my iPad and iPhone at home."
Deliver proactive notifications	Promotes adherence to self-monitoring and behavioral regularity	"I also just found emoods for my smartphone. I am just now starting to like it but I need to set an alarm to do it."
		"I am so chaotic I find it difficult to keep track of anything without help and prompting."
Synthesize data and highlight patterns	Increases self-awareness and reflection	"It has helped me see general patterns and to recognize personal triggers. And the more aware I am of the symptoms, the more I can do proactively."
Provide encouragement messages and rewards or (after non-compliance) flexibility and forgiveness	Provides experiences of mastery and cultivates self-efficacy and self-compassion	"My first few episodes I felt intensely guilty about failure. It was this intense guilt that made me feel suicidal. Recognizing symptoms of depression has allowed me to be much more forgiving during episodes."
Integrate with clinical care while respecting existing practices via doctor-view interfaces, digestible summary reports, and modifiable settings	Facilitates improved acceptance, transmission, and interpretation of information by treatment teams	"I find that the reports succinctly provide my doctors with a more accurate picture over time than what I can recall at any given time. It also helps me to create a dialogue with my providers other than the fact that I don't feel well (mentally). It has also helped my providers to see symptoms and patterns that I wouldn't have thought to mention in short, 15 minute appointments."
		"I tried to share optimism [tracking app] but my Dr was confused by the graphs."
Provide BD-oriented functionality	Allows tracking of BD-significant indicators	"I have not been able to find an app that I really like enough to use. One problem with charting apps is they don't allow you to chart more than one mood a day. If you have rapid cycling the app is useless."
Allow customization	Supports idiosyncratic circumstances, preferences, and goals, including how individuals' conditions and management practices and needs evolve over time	"Very tedious. Would prefer to customize the computer program to track routine, socializing, etc."
		"I used the app Optimism for about 4 months. It tracked 20+ elements. Recording the elements was good to make me aware/conscious of issues, but it only gave feedback/patterns on a few elements. I then switched to an elaborate excel spreadsheet that provided better feedback/patterns, but it ran off my laptop & wasn't 'handy'/convenient for tracking when I have time. Now my day is HIGHLY structured & my mood very stable. I now track in my head, have daily google calendar reminders, keep a running list to monitor elements, and have alarms that help with sleeping, eating, etc."
Implement user-friendly features	Alleviates hurdles to tracking, including during mood episodes	"I used to use a mood app I found on my phone but it was confusing so now I just use the notes section on my iPhone or an actual paper journal."
		"I find many of the mood tracking apps overly complex and overly rigid."
Passively monitor and intervene	Reduces users' efforts and burdens and supports continuous capture of data	"I used to use a calendar on my wall (for tracking), but I had a long mood episode of more than a month and quit tracking."

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