A Study on mHealth Adherence for Bipolar Disorder: A Case Study with the BraPolar2 Application

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Abstract: Bipolar disorder (BD) is a mental illness that affects 40 million people worldwide. Fluctuations in mood, activity, and self-awareness mark this condition. Studies using mHealth applications to monitor people with BD have shown promising results in the early detection of these fluctuations; however, they usually require participants to complete daily tasks in the app, which causes them to abandon the study and compromises the quality of the research. This paper explores the adherence to BraPolar2 mHealth through a set of development strategies. To identify the aspects that lead patients with BD not to complete daily data in an mHealth application and the factors that motivate them to use the application as a habit, we conducted qualitative research with BraPolar2 mHealth. Nine people with BD participated in the study and used BraPolar2 for more than 3 months, answering a semi-structured interview. The results show that users can fill in all the data quickly and begin to pay more attention to their mental health daily. The paper contributes by demonstrating how a simplified interface in mHealths, coupled with qualitative research, can lead to the participation of mHealth applications for mental health follow-up, allowing an improved follow-up in next studies.

1 INTRODUCTION

Bipolar Disorder (BD) is a mental condition characterized by extreme mood swings between emotional highs, called manic episodes, and lows, known as depressive episodes (Sajatovic et al., 2010). The term bipolar reflects these two extremes: during a manic episode, a patient experiences intense feelings of euphoria, sleeplessness, racing thoughts, impulsive actions, and risky behaviours (Sajatovic et al., 2010). In contrast, depressive episodes involve loss of interest and pleasure in activities, feelings of hopelessness, and low energy, making even the simplest mundane tasks difficult (de Figueiredo et al., 2022). Without treatment, these mood swings become more frequent and intense, complicating the patient's ability to man-

age their routines. Although there are different types of BD, all are defined by mood swings; the difference lies in the frequency and intensity of these mood changes (Tondo et al., 2022). This condition makes managing daily social activities and functions such as work, relationships, and self-care extremely difficult as patients struggle to maintain emotional balance.

The most common way to monitor and treat patients with BD is through medication and scheduled appointments with healthcare providers. However, the time gap between appointments allows for unmonitored mood swings that may not be accurately reported during the next visit (de Figueiredo et al., 2022). Daily appointments are impractical, so a convenient solution is using mHealth applications to keep track of patients with BD (Chan et al., 2021).

Although these m-health apps ensure consistency and frequency in collecting data to support tracking mood swings, these applications would be limited if the user showed low adherence to the app. Adherence

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to mHealth is defined by how well the user follows the app's protocols, considering their frequency of use and duration of time of use. In addition, mHealth apps also offer benefits such as lower costs due to more spaced appointments and more reliable daily data collection (Chan et al., 2021).

This article presents the BraPolar2 development process (Mondéjar et al., 2024), an application to monitor people with BD. We discuss and evaluate BraPolar2 adherence in nine people with bipolar disorder as the reasons why these BD patients show higher or lower levels of adherence to the app, abandoning or discontinuing the use of the app in some cases, despite knowing that it helps them collect daily data about their mental state. This study analyzes patient interaction with BraPolar2 and semi-structured interviews with patients who used the application for at least 3 months. Using the adaptation of the mHealth Usability Questionnaire (MAUQ) (Muro-Culebras et al., 2021), we focused on the patient's motivations, reasons for daily use and factors contributing to inconsistent use of the app.

This article is structured as follows. Section 2 presents related works, and Section 3 details the adherence strategies, development and MAUQ presentation. Later, in Section 4, we present the methodology and evaluation procedure with bipolar patients in an ambulatory clinic. Finally, Section 5 describes the results and presents the discussion, limitations, future work and conclusions in Section 6.

2 RELATED WORK

Developing mHealth apps for patients with mental illness can be challenging depending on the type of illness being treated and the illness-related factors (Vöhringer et al., 2013) and therefore requires specific design choices. mHealth applications are intended to provide support for the outcome of mental ill patients in many different ways, such as symptom monitoring apps where the patient can report their symptoms during the day, remote consultations, medication management reminding the patient to take their medication, and cognitive behavioral therapy (CBT) tools that allow the patient to use some alternatives to help manage conditions such as anxiety and depression (Batra et al., 2017). Recent research shows that the main factors that influence users to first adopt mHealth apps are social influences, such as internet findings, comments, and reviews on apps (Woldeyohannes and Ngwenyama, 2017). However, adherence level would depend on the type of mHealth app being used, the friendly interface, and the develop-

ment of a habit during the time period of use (Woldeyohannes and Ngwenyama, 2017).

Knowing that BD is characterized by unstable moods that vary from depressive states to euphoric states, it is interesting both for the patient and their doctor that these mood swings remain trackable and under constant observation (de Figueiredo et al., 2022), mHealth applications (Mondéjar et al., 2019) (Mondéjar et al., 2020) turn daily mood reports into reality, requiring the patient to fill in only a simple questionnaire on his phone.

Furthermore, despite the heterogeneous mHealth apps available for download nowadays (Batra et al., 2017), these applications remain rarely implemented in treatments (Patoz et al., 2021). After downloading, the user quickly abandons them (Baumel et al., 2019), further strengthening the need for more studies on lack of adherence when it comes to adherence of patients with bipolar disorder to mHealth apps. These studies are relevant because the mood swings make BD a unique case among mental illnesses, as these swings can specifically affect adherence levels when it comes to treatment (Sajatovic et al., 2010) and will be dicussed in the next section our proposal.

3 BraPolar2 AND ADHERENCE STRATEGIES

Despite the findings in current literature regarding adherence to mHealth, in this section we present four adherence strategies developed to reduce the lack of adherence to mHealth. Later, we develop a new version of BraPolar2 and present the evaluation test to be applied.

3.1 Adherence Strategies

Non-adherence to mHealth applications to monitor people with bipolar disorder can lead to incorrect diagnoses by specialists (Jakob et al., 2022) (Siegel-Ramsay et al., 2023). With this new version, we aim that BraPolar2 (Mondéjar et al., 2024) were to be less intrusive in the day-to-day collection of active user data, following this background approach of collecting subjective information, we could get valuable information that users could forget about on a specific day when asked in consults or feel uncomfortable (Siegel-Ramsay et al., 2023). In this line, as adherence to mHealth is a challenge mentioned in the literature (Patoz et al., 2021) (Averous et al., 2018), we propose that the new version of BraPolar (BraPolar2) should address the following points:

1. Simplified user interface (UI).

2. Regular feedback loops and progress tracking.

3. Lower power consumption for extended battery.

4. Offline functionality for no-internet areas.

With those four considerations, we developed a new version of mHealth supported by psychiatrists and psychologists from the Institute of Psychiatry of the Federal University of Rio de Janeiro (IPUB). This psychiatric institution maintains clinical research in psychoanalysis. The next subsection details the BraPolar2 development process and how we adapt the four-adherence proposal to this new version of mHealth.

3.2 BraPolar2 mHealth Development

BraPolar2 is a mHealth that captures active and passive data from bipolar patients. Although active data requires conscientious data into patients' mHealth, passive data is collected using smartphone sensors. The detailed development process of this mHealth was described by Mondéjar et al. (Mondéjar et al., 2024), considering previous work experience (Mondéjar et al., 2019) (Mondéjar et al., 2020) and adherence strategies described above.

Summarizing the BraPolar2 development process, we could highlight that psychiatrists and psychologists participated in all stages of the Software Development Life Cycle (SDLC) (Agarwal et al., 2023) defining the main features or requirements to be collected with BraPolar2 such as mood, mood intensity, energy level, sleep and sleep quality, medication and menstrual cycle and the sequence of interfaces with which patients interacted during the investigation regarding the request of medical personnel.

Once the application was developed, we collected the digital phenotype in BD patients. Meanwhile, as adherence in mHealth is of considerable relevance for collecting digital phenotype, we investigated how to evaluate the adhesion and acceptance to the application. In this way, we proceed with an mHealth app usability questionnaire (MAUQ) adaptation into a semi-structured interview, as detailed above.

3.3 MAUQ

When exploring adherence to apps, one way to gather material for evaluating the factors that influence the degree of adherence is by applying a usability questionnaire. This tool is used to evaluate the user experience when using an application. These questionnaires measure aspects of the application's usability, such as

ease of use, utility, and user satisfaction, so that the responses obtained help developers identify the application's strengths and weaknesses that can be improved (Zhou et al., 2019).

To identify the aspects that cause patients with bipolar disorder not to fill in the data in a mHealth application and the factors that motivate them to use the application as a habit, we conducted qualitative research on the use of mHealth BraPolar2 supported by an adaptation of the mHealth Usability Questionnaire (MAUQ) (Muro-Culebras et al., 2021). These questionnaires aim to measure different aspects of the usability, satisfaction, and acceptance of mHealth apps among users and healthcare professionals. In addition, it is widely used in the field of study by other authors (Manzano-Monfort et al., 2023) (Mustafa et al., 2021) (Hajesmaeel-Gohari et al., 2022) who adapt to their native language, then we proceed to adapt it to our context, described below.

In the next section, we present the methodology, highlighting the steps taken to evaluate adherence in this study.

4 EVALUATION

In this section, we present and adapt the MAUQ questionnaire into a semi-structured interview and ethical considerations. Finally, we comment on the data collection procedure when the interview was conducted with nine bipolar patients.

4.1 MAUQ Adaptation Interview

Although MAUQ is designed primarily as a self-administered questionnaire, it can also be adapted for interviews to gather more in-depth qualitative insights into user interactions with mHealth applications, considering that long questionnaires can potentially lead to respondent fatigue, impacting the quality of the collected data (Glise et al., 2020). Consequently, we adapt MAUQ for BraPolar2 to determine whether patients adhere to the app through an interview script.

This adaptation study matches the MAUQ model, as it is split into four subscales focused on ease of use, interface satisfaction and utility, resulting in more reliable responses from the interviewed users (Zhou et al., 2019). To adapt the script to make it fully understandable for the participants (Brazilian patients with BD), we follow the following steps:

1. Translation to Portuguese MAUQ questionnaire.

2. Adapt him to conduct a semi-structured interview.

3. Validate it with psychiatrists and psychologists.

As conducting an interview can be challenging, we obtain a questionnaire to assess adherence in a semi-structured interview, avoiding closed questions and intending to be an open-ended question that promotes discussion and leads to a conversational partnership (Lazar et al., 2017) (Grande et al., 2019) (Grau-Corral et al., 2020). As part of the preparation, we applied a pilot interview test with six specialists (two psychologists and four psychiatrists) to refine the questions for the patients.

Once we have concluded that this phase is over, we intend to know the easy and frequency of use, motivation, satisfaction with interface, utility, feelings towards collected passive data and general opinion. Then, with the translated MAUQ model, an adaptation was made so that the questionnaire could be applied to assess the usability of the BraPolar2 app.

4.2 Ethical Considerations

Ethical considerations are highly relevant in mHealth when collecting people's information. As mHealth technologies raise unique risks to user privacy and confidentiality, often embedded in lengthy and complex user agreements (Gelinas et al., 2023). In this line, we care about the Brazilian legal base, data protection laws, rights over users' data, anonymity, and the security process of collected information. For all interviews conducted, patients signed an informed consent form (ICF) stating that they agreed to record their voices and would be analyzed to publish scientific research.

4.3 Participants

We met with psychologists and psychiatrists to define inclusion and exclusion criteria to recruit patients with BD. As a result, we included people diagnosed with BD between 18 and 60 years old. We excluded patients who were pregnant, had a lack of knowledge of the Portuguese language, who could not learn the technical details of using a smartphone, and who were seriously ill or also diagnosed with schizophrenia, schizoaffective disorder or delusional. Regarding the quantity and demographic characteristics of the participants, nine (seven women and two men) aged 21 to 48 years were enrolled. They used BraPolar2 for at least 3 months from the beginning of the research.

The participants were labeled from P1 to P22. We intend to reach those participants who decided to abandon the research (P1, P6, P7, P9, P10, P14, P17, P19, P20, P22) too; however, it was not possible due to their free decision to stop the research. Furthermore, we focus on nine people with bipolar disorder

who participated in the study and used BraPolar2 for at least three months from the beginning of our research. To be as less intrusive as possible, the interview occurred during one of their regular consultations while waiting for their medical appointment in IPUB Institute. First, we invited patients to participate in the research and proceeded to sign the ICF; neither one refused to participate or record their voice and was invited to a consultation room where the questionnaires were applied, recorded and analyzed by the researchers later.

The following section presents the main user adherence results using the MAUQ interview collection method.

4.4 Data Collection Procedure

The interviews were conducted at IPUB, where the participants were already waiting to be seen by their psychiatrists. The interviewers sat beside the participants, reading out loud the MAUQ adapted script and listened to the participants' answers. Due to the place being usually crowded and limited in space, the interview had to be interrupted because the patients were called during it, resulting in the data being split into two different audio files. The interviews lasted an average of 15 minutes in total, with the longest lasting 21 minutes; a total of 9 interviews were conducted, all of which were first recorded using the interviewer's phone voice recorder app and later transcribed, facilitating the analysis of the collected data.

Once the interviews were complete and properly transcribed, many sentences were disregarded for the final analysis as they were irrelevant to the study. Such parts included sentences spoken by third parties not participating in the interview or segments where the participant or interviewer strayed from the interview topic. Once this filtering was performed, the transcription was organized by the topics of each set of questions asked.

In the next section, we present the results with BraPolar2 on active data and qualitative research from MAUQ.

5 RESULTS

In this section, we describe the main results of the research on the adherence of the user to BraPolar2 and the main findings. First, we describe the main results of the investigation regarding the user's adhesion to the proposed solution and the main findings.

The interviews with the modified version of MAUQ were conducted at different times for each

participant. In addition, we include their current state on the day of the interview (manic, hypomanic, euthymic, or depressed) defined by their therapists, considering that patients with bipolar disorder can exhibit varying levels of understanding and insight into research participation based on their current mental state (Misra et al., 2008) and the total interview time in mm:ss (TT), summarized in Table 1 and is commented on in detail in the discussion subsection (5.1).

Table 1: Patient state in interview day.

ID	Date	Mental State	TT
P2	04/06	Manic	10:38
P3	04/06	Hypomania	16:36
P5	21/05	Depressed	14:15
P8	21/05	Euthimia	21:49
P11	07/05	Depression	18:24
P15	28/05	Depression	14:53
P16	14/05	Euthimia	11:58
P18	04/06	Euthimia	08:58
P21	21/05	Euthimia	21:44
Avg time	-	-	**15:28**

Although we have continuous follow-up and patient recruitment, some participants decided not to continue (P1, P6, P7, P9, P10, P13, P14, P17, P19, P20 and P22); we observed that they were not interested and left to complete the daily questionnaire or did not return to IPUB on the scheduled date and summarized the reason for the abandonment of the study. P1, P6, P17 and P22 withdrew immediately after their first consultation. P7 and P10 faced technical or compatibility issues with the app, and P9-10 cited personal or workload constraints to continue, and P13 P14 presented more complex mental health. Finally, P19 and P20 transitioned to private consultation.

In the next section, we discuss the feedback from those participants who completed the minimal assessment time of three months.

5.1 Discussion

Interview analysis may be challenging (Lazar et al., 2017) (Barbosa et al., 2021). Taking into account the notes and prescription of the audios mentioned in the interview, we analyze each prescription, split into categories (Lazar et al., 2017): ease and frequency of use, motivation, satisfaction, utility, and an open question called general user opinion.

Ease of Use. The participants considered the application practical and easy to use, with some initial challenges overcome with practice. First, P2 described the application as practical and easy to use, quickly overcoming the initial difficulties. P5 found the application very easy to use, highlighting the smooth navigation between screens and the ability to enter the necessary information without problems. P8 found it difficult to view the history of his entries, which negatively impacted his motivation for continued use and the lack of reminders. P11 mentioned that the restricted time to enter the data was a significant problem, resulting in the loss of records. Furthermore, navigation, although generally consistent, presented some glitches. P15 found using the application intuitive, with clear questions and objective markings and did not face significant difficulties in navigation. P16 considered the application easy to use, mentioning that alarms and reminders were not uncomfortable, although he occasionally forgot to respond due to routine. P18 also found the application easy and intuitive but noticed that the answers were reset when returning to a previous page, which was an issue solved later.

Frequency of Use. Regarding the frequency of use, participants showed variations in the frequency of using the application, influenced by different factors. P2 used the application daily, feeling satisfied and with a sense of mission accomplished after filling in the daily data. P5 highlighted that the lack of availability at certain times affected their frequency of use, emphasizing the importance of having more flexible schedules to facilitate continuous use. P8 mentioned that the absence of reminders negatively affected her frequency of use, indicating that she would have used the application more regularly if she had been notified at specific times. P11 used the application daily, except when he forgot or missed the time allowed for data entry, considering this restriction a significant impediment to continued use. P15 used the app almost daily but occasionally forgot, especially when he was away from home or feeling ill. He felt frustrated when he could not fill in the data after midnight due to the impossibility of retroactive entry. P16 used the application daily but sometimes forgot to fill in the data, especially at night, feeling bad when he could not complete the entries for several days. P18 used the application daily, except on some days when she forgot, usually due to her menstrual routine, feeling frustrated when she failed to fill in the data.

Motivation. The participants presented different motivations for using the application, often related

to their daily routines and personal needs. P2 preferred to fill out the information at night, as this coincided with when she took her medication, helping her to remember this important task. P5 felt that the app helped record her mental state, providing self-awareness of her mood and sleep. The absence of a visual history impacted P8's motivation as she would like to see her progress over time, especially concerning personal aspects such as menstruation. P11 did not directly discuss her motivation, but her regular use suggests that she was committed to the process despite the app's limitations. P15 preferred to use the application at night, after completing his daily activities and taking medication, considering filling in the data as a diary that provided a positive feeling of control over his data. P16 also preferred to fill in the data at night, but suggested that answering in the morning could be more accurate, especially for questions about sleep and medication. P18 preferred to complete the data in the evening, to ensure that all changes in mood throughout the day were captured.

Satisfaction of Use. The participants presented different opinions on the application interface, highlighting positive aspects and suggesting improvements. P2 liked the interface of the application, thought the information was well organized, and felt comfortable using it in social environments, considering the time spent using it as appropriate and expressing general satisfaction with the application, stating that he would use it again. P5 described the interface as organized and easy to use, as well as comfortable in social settings. Considering that the usage time is adequate, it generally takes around five minutes to complete the entries. P8 found the interface neutral and mentioned that the information was well organized, but felt a lack of adequate notifications and feedback on information entered, feeling comfortable using the application in social environments, but not satisfied with the current version, highlighting the need for improvements to increase usefulness. P11 described the interface as basic and normal, with well-organized and intuitive information, feeling comfortable using the application in social environments, but preferring to use it before bed. P15 considered the application interface simple but suggested improvements to align with more modern designs, including accessible graphics and results for users. P16 considered the application interface simple and well organized, comfortable using the application in social settings, and found the time spent adequate. P18 liked the app's interface, found the information well organized, felt comfortable using the app in social settings, and found the time spent appropriate.

Utility. Participants expressed different perceptions about the app's usefulness for their health and well-being. P2 found the app useful for remembering to take her medication and managing her bipolar disorder, believing that the app had all the necessary features. P5 considered the application useful for understanding and managing his mental state, but suggested improvements such as greater schedule flexibility (insert the information at any moment of day). However, P8, did not find the application useful due to the lack of access to recorded information and the lack of feedback on his daily entries, which diminished his perception of usefulness. P11 also did not find the app particularly useful for monitoring her mood, citing the lack of transparency about where her data go and the lack of practical use in everyday life, highlighting the need for more transparency and features in future versions. P15 believed in the app's usefulness for mental health, especially if used in conjunction with a psychiatrist or psychologist, suggesting the presentation of graphical results to help users better understand their mood fluctuations. P16 found the application useful, especially for remembering medications, suggesting the inclusion of a field for personal observations to better contextualize the data collected. P18 also found the app useful for keeping track of her mental state, but would like access to visual feedback, such as graphs, to better understand her mood trends.

General User Opinion. The participants presented valuable suggestions to improve the usability and effectiveness of the application, with an emphasis on flexibility and data presentation. P2 highlighted the importance of the application in improving your day and positively incorporating it into your daily life. P5 suggested greater flexibility in the times to fill in the information to facilitate the continuous use of the application. P8 recommended leaving the field of emotions open without limiting it to predefined options and eliminating the time limit to fill out the information, which would increase the flexibility and usefulness of the application. P11 did not directly mention feelings about passive data collection. Still, it highlighted the need for greater transparency, suggesting clearer communication about collecting and using these data could improve their satisfaction. P15 emphasized the need for improvements to the interface and presentation of the results, suggesting that these changes would increase the satisfaction and effectiveness of the application. Both P16 and P18 suggested the inclusion of graphs and analyses of the collected data, which would help better understand trends and variations in mood over time. P18 also mentioned that allowing the correction of the answers

without losing previous data would improve usability and overall satisfaction with the application.

In summary, we point out two main reasons people abandon ongoing research: personal (un)interest and lack of commitment. As research participation is voluntary and personal interest can vary, we were interested in gaining information about those participants who decided to continue with research and their experience with the BraPolar2 application. Consequently, we apply a qualitative evaluation through an adaptation interview of MAUQ. At this point, we could consider the diverse circumstances of a lack of acceptance of the research described next.

5.2 Limitations of the Study and Areas for Future Research

The first methodology option considered for collecting data for this study was a Google Forms questionnaire style. However, the number of participants turned out to be too low for such a form to guarantee both comprehensive and accurate results. The solution was to conduct oral interviews, allowing participants to elaborate further while answering interview questions.

Several challenges found during the interviews were related to the patient's state during the interviews, which was the ability of each patient to respond to the questionnaire in a coherent way. When it comes to BD, some patients could be found either on a extreme manic state or depressive state, affecting their capacity to maintain focus or interest on some of the questions asked. One interesting case to report was P3, who had returned after months without coming to the IPUB institute and talked a lot about personal matters and less about the questions made during the interview itself. She got dispersed a lot of times and we, as the interviewers, struggled to keep the interview on track. Although there were some other patients like P3, there were also some who were less communicative, giving short kinds of answers and not elaborating much during the conversation, In contrast to P8 who talked for 21 minutes while the average interview time was around 15 minutes.

6 CONCLUSION

This study presents the relevance of BraPolar2 mHealth for an enhanced management of bipolar disorder, applying a set of strategies to improve the adherence and tested with nine bipolar disorder patients.

As a result, the app was well-received for its relative ease of use and utility. However, improvements in user feedback to enable more flexible data entry functionality, visual progress tracking, and interface design can help increase satisfaction and engagement with the app. One significant advantage also is awareness of emotions and help in the management of bipolar disorder, which makes this application useful. As mHealth continues to evolve, more studies with a longer collection time and gamification techniques can be developed to improve adherence in patients with bipolar disorder and mHealth, improving patient outcomes and quality of life.

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