Journal of Affective Disorders 200 (2016) 58–66

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Psychoeducation in bipolar disorder with a SIMPLe smartphone application: Feasibility, acceptability and satisfaction

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ARTICLE INFO

Article history:
Received 1 March 2016
Received in revised form
11 April 2016
Accepted 16 April 2016
Available online 20 April 2016

Keywords:
Bipolar disorder
Psychoeducation
Smartphone
Application
SIMPLe

ABSTRACT

Background: During the last fifteen years, the possibility of delivering psychoeducation programs through Internet-based platforms have been explored. Studies evaluating those programs have shown good to acceptable retention rates. In this context, we developed a smartphone application (SIMPLe) collecting information about mood symptoms and offering personalized psychoeducation messages. The main aims of this study were to evaluate the feasibility, acceptability and satisfaction of the smartphone application.

Methods: The study was conducted from March to August 2015. Participation in the study was proposed to a consecutive sample of adult patients attending an outpatient mental health clinic. Sociodemographic data, clinical and functional assessments alongside smartphone ownership and uses were collected at baseline and at 3 months' follow-up. A 5 item Likert-scale satisfaction questionnaire was also employed.

Results: 51 participants were initially enrolled in the study, 36 (74%) remained actively using the application after 3 months. The whole sample interacted with the application a mean of 77 days (SD = 26.2). During these days they completed 88% of the daily tests. Over 86% of the participants agreed that the experience using the application was satisfactory.

Limitations: The diversity of smartphones operating systems led to a moderate, although representative, sample number. Additionally, the subjective data reporting, narrow time frame of use and stability of the patients could have affected the results.

Conclusions: The results confirm that this particular intervention is feasible and represent a satisfactory and acceptable instrument for the self-management of bipolar disorder as an add-on to the usual treatment but future clinical trials must still probe its efficacy.

1. Introduction

The estimated prevalence of bipolar disorder (BD) in the general population is estimated to be around 2%, although this could have been underestimated due to undiagnosed cases (Fagiolini et al., 2013). Besides the well-known behavior changes during pathological mood episodes, BD has a serious impact on psychosocial functioning, cognition, quality of life and survival of those affected (Catalá-López et al., 2013). Some pharmacological treatments and adjunctive psychological interventions have shown to improve the long-term outcome of the disorder (Grunze et al., 2013; Reinares et al., 2014).

Among psychological interventions, psychoeducational programs proved to be a cost-effective approach to help patients improve adherence, regularity of habits and recognize early signs

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http://dx.doi.org/10.1016/j.jad.2016.04.042
0165-0327/

and symptoms in order to prevent episodes (Colom et al., 2009; Scott et al., 2009). However, although there is an increasing demand from patients and their relatives to receive this kind of treatments, its availability is still limited due to the costs and resources involved (Miklowitz and Scott, 2009). The implementation of psychoeducation programs require trained specialists and specialized units (Colom, 2011). Unfortunately, this combination is available only at very few centers around the globe. Moreover, from the patients' side, it requires attendance to weekly sessions during a period of about 6 months. This may limit its implementation in large countries and rural areas with long geographical distances between the patient and the care center. Besides the aforementioned challenges, tailoring these interventions to individual clinical characteristics and schedules in a cost-effective way are difficult aims yet to be addressed. For these reasons, there is an increasing need to find new efficient methods to deliver and extend psychoeducation programs to a wider population of patients with BD.

During the last fifteen years, several projects have explored the possibility of delivering psychoeducation programs through Internet-based platforms such as web-sites and mobile devices (Cosgrove et al., 2013; Depp et al., 2014; Meiser et al., 2013). These platforms offer the patients the possibility to access the program according to their schedules even if they live in remote areas, something which represents a very attractive complement to the standard treatment (Holländare et al., 2015; Palmier-Claus et al., 2013; Parmanto et al., 2013). Studies evaluating these programs have shown good to acceptable retention rates of about 50–80%; however, due to the extreme heterogeneity in outcome measures and methodologies used, it is still not possible to draw sound conclusions about their long-term efficacy (Hidalgo-Mazzei et al., 2015a).

On the other hand, the wide availability, constant miniaturization and increasing computing power of mobile devices make it possible to obtain a reliable and continuous collection of relevant users´ information at a low-cost. Smartphones, through the increasing embedded sensors and daily usage patterns, can collect a vast amount of objective information to identify behavioral symptoms patterns as well as physiological signs, which have the potential to provide novel insights about mental illnesses (Munk-Jørgensen et al., 2014). Moreover, this still underutilized kind of data have recently shown to be a feasible potential biomarker of illness activity in BD (Faurholt-Jepsen et al., 2015, 2014).

Based on an increasing number of studies, it seems that smartphones technology is perceived by the patients as a comfortable, time-unconstrained, user-friendly and non-invasive method in the self-management of their mental health (Bush et al., 2013). Furthermore, it makes possible to register and monitor relevant signs and symptoms in real-time (Faurholt-Jepsen et al., 2015). In addition, it can provide continuous self-managed psychoeducational contents, which can be tailored to the specific needs of each individual based on their smartphone data (Ben-Zeev et al., 2013; Torous et al., 2015).

As an initial phase of the SIMPLe project (Hidalgo-Mazzei et al., 2015a), we initially set out to develop a smartphone application (SIMPLe 1.0) collecting information about potential bipolar symptomatology (i.e. subjective information), with the additional advantage of offering personalized psychoeducation messages and alerts delivered to the patient. The application is intended to be an additional tool to the usual treatment. Before testing its efficacy and due to the novelty of the intervention, it is mandatory to carry out a rigorous feasibility study in a real-world clinical setting in order to ensure the acceptability, satisfaction and safety of these interventions and increase the chances of reaching some degree of engagement in the long term (Bowen et al., 2009; Wenze et al., 2014).

Accordingly, the main aims of this feasibility study were to evaluate, during 3 months, acceptability, safety and satisfaction of the SIMPLe smartphone application designed to monitor symptoms in BD, offering customized embedded psychoeducation contents and empowering self-management. Secondary objectives were to explore whether sociodemographic and clinical variables of the sample could predict or enhance the usage of this application. Additionally, patients' suggestions and comments regarding the application were collected during the study in order to improve further versions.

2. Materials and methods

2.1. Participants, procedure and measures

The study was conducted from March to August 2015. Participation in the study was proposed to a consecutive sample of adult patients attending the outpatient mental health clinic of the Bipolar Disorders Program in the Hospital Clínic of Barcelona. The eligibility criteria included a diagnosis of a BD type I, II or not elsewhere specified (NES) based on DSM-5 criteria. The study was approved by the Ethics Committee of the Hospital Clínic of Barcelona and registered at clinicaltrials.gov (Identifier: NCT02258711).

If the patient met eligibility criteria, their usual psychiatrist or psychologist explained briefly the aims of the study, the intervention and enquired if they were interested. If this was the case, an independent researcher extended a brochure with all the information and requirements regarding the study. At this point the patient could choose whether to participate or not, based on their will or if they have a compatible smartphone (i.e. Smartphone with Google™'s Android Operating System version $>=4.0$). In case of denial, the reason, gender and age of the patient were also registered. If the patient agreed to participate, an informed consent was handed out and, upon acceptance, signed by the participants. Since the ultimate goal of the intervention was relapse prevention, to be included participants had to be euthymic, determined by a current Hamilton Depression Scale (HDRS; (Bobes et al., 2003; Hamilton, 1960)) score below 8, and a Young Mania Rating Scale (YMRS; (Colom et al., 2002; Young et al., 1978)) score below 6 (Tohen et al., 2009). Patients currently participating in group psychoeducation or with an intelligence quotient score below 90, were excluded from the study. Sociodemographic data and standardized clinical and functional assessments were registered at baseline and after three months. These included: manic symptoms using the YMRS, depressive symptoms using the HDRS as well as Functional Assessment Short Test (FAST) (Rosa et al., 2007) and treatment adherence using the Morisky-Green 8-item test (Morisky et al., 1986). In addition, information about smartphone most common uses and ownership time were collected. No rewards or incentives were offered to the patients for their participation or completion.

After study inclusion, a random identification six-digit username and password were provided to each participant. This username was linked to their electronic health records (EHR) identifier in a completely independent encrypted database. According to the research protocol, de-identification process was activated if there was an emergency detected by the application (i.e. suicide ideation) and treating psychiatrist was alerted, in order to contact the patient.

At the end of the first interview, the researcher helped the patient to install the application in their own smartphones, log into the system and a brief explication on the application was provided. Since the application was designed to be user-friendly and self-explanatory, no further information or training was

offered to the patients during the study period besides the embedded standard tutorials within the application. The only exception was if technical issues were experienced by the user, in which case a telephone number was provided to contact the researcher for further assistance.

Three months after enrolment, a second interview was carried out by the same researcher and follow-up assessments were conducted. At the end of this interview, patients were handled a 5 item Liker-scale self-questionnaire enquiring about four main topics: 1. Overall experience satisfaction, 2. Utility according to their condition and clinical state, 3. Discretion and invasiveness on daily usage, and 4. Technical difficulties experienced. Suggestions and comments of the patients about the application were also registered. During the study period neither the researchers nor the psychiatrists /psychotherapist were blinded, however they were not explicitly informed about the patients' participation or use of the application.

2.2. The intervention SIMPLe 1.0

The intervention is based on contents of an evidence-based group psychoeducation program for BD (Colom et al., 2009, 2003). A user-centered design (UCD) approach (Roth et al., 2014) was adopted for the development process in order to increase the chances of a higher user satisfaction and retention. During 1 year, potential users (i.e. patients), international field experts, software engineers and graphic designers were involved in a collaborative and iterative process. This process included individual interviews, focus groups, online surveys and forums, as well as small alpha and beta test groups (Fig. 1). At the end of this phase, the smartphone application employed (i.e. SIMPLe 1.0) for the study was available in Spanish language and free of charge for smartphones with Android Operating System 4.0 or higher.

The overall functioning of the application is intended to be minimally invasive to the users' daily routine and normal smartphone usage. Its ultimate aim is to collect enough information from ecological momentary assessments (EMA) (Ebner-Priemer and Trull, 2009) to adapt psychoeducational messages according to the clinical states, potential relapses and risk situations. Accordingly, the application prompts the user to answer a daily short graphic 5-item screening test (i.e. mood, energy, sleep time, medication adherence and irritability) and a weekly, more comprehensive YES or NO test, considering all DSM-5 criteria for manic and depressive episodes including suicide thoughts. System notifications pop-up in the smartphone reminding of a pending test at the time configured by the user. If an algorithm in the score of the daily test detects relevant clinical variations, the user is requested to take up to two extra additional week tests per week. During the week tests, if the patient answers affirmatively to the question about suicide thoughts an automatic alert email is sent to the research team and the patient is offered to call the emergency services from their own smartphones. This feature was added according to ethical standards and local legal regulations. At the end of the tests, a short message about the clinical state is displayed. Daily, a pop-up notifies the user to open a short psychoeducational message of no more than 100 words. This message is extracted from a library of more than 500 messages categorized according to different clinical situations. An algorithm determines the category of the messages to display based on the answers of the weekly test. All the messages in the library were written by BD experts (MR, FC) and were based on an evidence-based group psychoeducation manual (Colom and Vieta, 2003) and other client-focused materials produced by the group. The messages provide the user a brief information or advices of how to deal with specific situations in order to avoid a relapse. During euthymic periods, most of the psychoeducational messages are about general information of the disorder including etiologic, diagnostic and therapeutic aspects. Both the time of to receive the notifications of the daily test and the psychoeducational could be configured by the user as well as the day of the week to receive the weekly test. Further specifications and the development process of the SIMPLe application 1.0 are described in further detail at the study protocol (Hidalgo-Mazzei et al., 2015b). A diagram of the general functioning of the application is shown in Fig. 2. Further specifications and the development process of the SIMPLe application 1.0 are described in further detail at the study protocol (Hidalgo-Mazzei et al., 2015b).

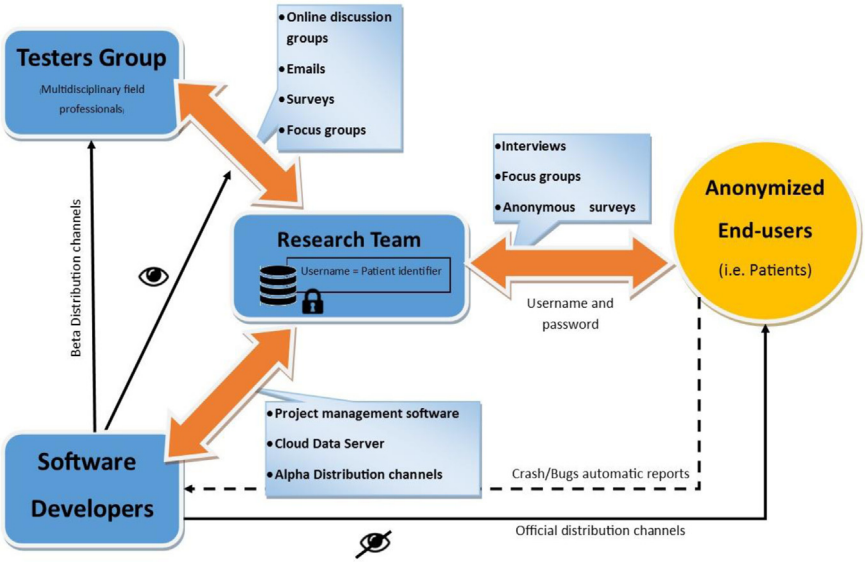

Fig. 1. SIMPLe 1.0 application development process with and for patients while preserving their identity. The figure summarizes the dynamic, iterative and collaborative process of the application development involving the Research Team, Software Developers, Testers (i.e. Mental health professionals, General practitioners, external software engineers, graphic designers) and End-users (i.e. patients). Special caution was taken in the communication framework in order to preserve patients' identity from Software developers and Testers. The feedback methods employed in the communications with each group are described in the boxes next to arrows. Eye icons next to arrows, represents the possibility or not to identify specific group in the communication channels. The database matching usernames and patients' identifier numbers was stored by the researchers in two independent encrypted storage units (i.e. Main and a backup copy) not connected to any kind of network.

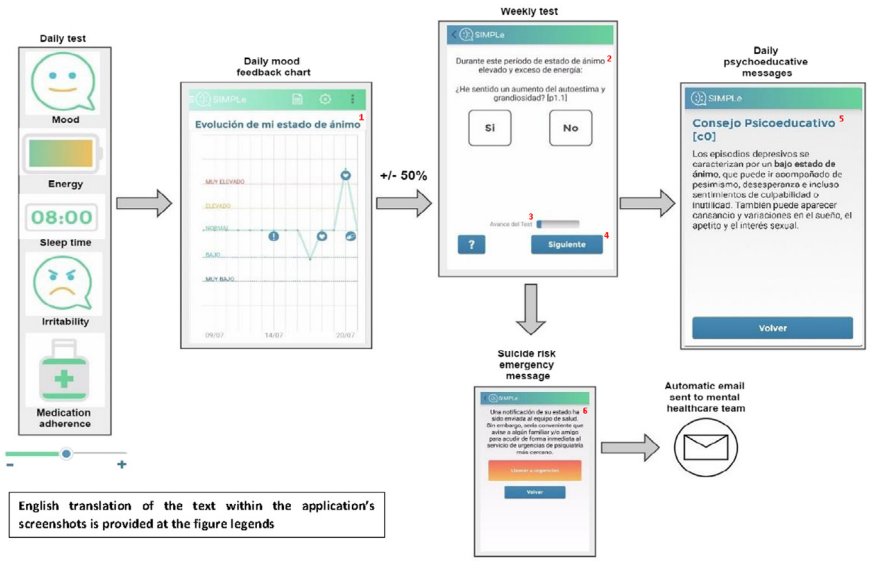

Fig. 2. The chart shows the method in which the application SIMPLe 1.0 provides psychoeducational messages as well as risk alerts based on the answers of daily and weekly tests. Superscripts numbers within the application screenshots offers translation of texts from Spanish to English accordingly: 1. Mood state progress, 2. During this time of elevated mood and energy levels: Did you experience an increased self-esteem and grandiosity? [Yes] [No], 3. Test progress, 4. [Next], 5. Psychoeducational advice. Depressive episodes are characterized by a depressed mood state which could be accompanied by pessimism, hopelessness as well as guilt and worthlessness feelings. Decreased energy as well as sleep, appetite and sexual interest changes could also be present [Back]. 6. A notification about your situation has been sent to the healthcare team. However, it would be important to contact immediately a relative or a friend in order to a hospital emergency department right away in order to be assessed. [Call emergency services] [Back].

2.3. Statistical analyses

In order to characterize feasibility, descriptive statistics were performed on the application usage data stored at the cloud server. Satisfaction, usability and acceptability were calculated based on the percentage of answers of the Likert-scale. Non-completers or dropouts were defined as those cases in which the server did not register any completed daily or weekly test over a 1-month period. Hence, we assumed that there was no direct interaction with the application or its potential benefits during this time according to the server's registration. Associations between demographic and clinical characteristics and retention rates at the end of the 3 months were explored with Pearson correlations. Subsequently, a binary logistic regression was performed to determine clinical predictors of retention controlling for potential confounding factors. Convergent validity between the punctuation on the daily test and the scores on the HDRS and the YMRS was analyzed using Person correlations. All analyses were carried out using SPSS version 18.0.

3. Results

3.1. Sociodemographic and clinical characteristics of the sample

Out of 85 individuals offered to participate in the study, 51

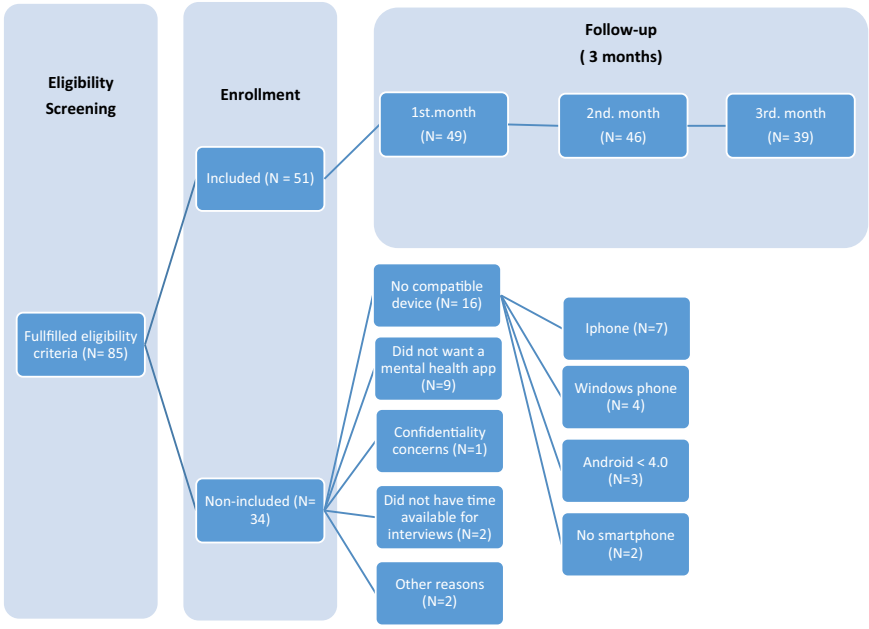

Fig. 3. The flowchart shows the number of participants at each step of the study procedure. Also the reasons given by non-participants.

Table 1
Baseline sociodemographic and clinical characteristics of the sample.

	Mean	SD
Age	43.92	11.36
	N	**Percentage**
Sex		
Male	28	57.1
Female	21	42.9
Educational level		
Low	10	20.4
Medium	9	18.4
High	30	61.2
Marital status		
Single	22	44.9
Married/Cohabitating	20	40.8
Divorced/Separated	7	14.3
Employment status		
Employed	21	43
Unemployed	4	8.2
Permanent disability leave	20	40.8
Retired	4	8.2
Type of Bipolar disorder		
Bipolar disorder type I	33	67.3
Bipolar disorder type II	13	26.5
Bipolar disorder NOS	3	6.1
Comorbidity		
Medical comorbidities	20	40.8
Anxiety disorders	2	4.1
Personality disorders	6	12.2
Substance use disorders	17	34.7
Medication adherence		
Low	0	0
Moderate	5	10.2
High	44	89.9
Predominant polarity		
Manic	20	40.8
Depressive	11	22.4
Undetermined	18	36.8
Family History of psychiatric disorder		
None	12	24.5
First degree	26	53.1
Second degree	9	18.4
Third degree	2	4.1
Course		
Rapid cycling	5	10.2
	Mean	**SD**
Manic episodes	2.06	1.83
Hypomanic episodes	1.24	1.61
Depressive episodes	2.14	1.29
Total episodes	5.44	3.00
Age of onset (years)	31.22	13.08
Episode density	0.77	1.10
YMRS	2.14	2.63
HDRS-17	3.18	2.69
FAST	12.83	12.29

YMRS= Young Mania Rating Scale, HDRS-17=17 item Hamilton Depression rating scale, FAST = Functioning assessment short test.

were initially enrolled. A flowchart of the study is depicted in Fig. 3, including the main reasons of refusal to participate from the 34 eligible non-participants. Non-participants had a mean age of 44.5 years (standard deviation, SD=12.9) and there was a predominance of women (69.4%). Two patients accepted to participate but never installed the application, hence these users were not considered in the analyses.

The baseline sociodemographic and clinical characteristics of the 49 participants are detailed in Table 1. Mean age was of 43.9 (SD=11.36) among participants. Most of these individuals had a high education level and a significant percentage (40.8%) was in permanent disability leave.

The vast majority of the patients had a BD type I and high comorbidity with medical and substance use disorders. Mean duration of illness was 12.7 years (SD=9.5). The total FAST scored a mean of 12.83 (SD=12.29) indicating functional disability, as the cut-off point of the overall FAST indicative of significant disability has been established above 12 (Rosa et al., 2007). Every participant was treated according to international clinical guidelines on BD which included pharmaco- and psychotherapy (Grunze et al., 2013; Nivoli et al., 2012, 2011).

3.2. Smartphone usage

Participants had been using a smartphone for a mean of 3 years (SD=1.26) prior to study entry. The most common smartphone uses were texting (96%), sending and receiving mails (71%) and social networking apps (59%). To a lesser degree, participants used their smartphones to read news and navigate the web (53%), listen to music (37%) and watch videos (18%). A small percentage of patients reported employing their devices to play videogames (12%) and geolocation (12%). None of the participants reported having used mental health applications before.

3.3. Feasibility

After the first month of the application use, 46 patients (94%) remained actively using the application, the active users dropped to 40 (82%) and 36 (74%) after 2 and 3 months respectively. None of the patients of the drop-out group reassumed the use of the application after 1 month of non-activity. The whole sample interacted with the application a mean of 77 days (SD=26.2) from a total of 90, while the interaction rate was of 1.3 times per day. During the days the participants remained using the application they completed 88% of the daily tests and 100% of the weekly tests requested. A total of 10 suicide alerts were received through the application and appropriate measures were taken by the healthcare team, which subsequently contacted the patients to assess the situation. Four of these alerts were false alarms as a consequence of the patients being testing the system.

3.4. Satisfaction, acceptability and usability

Over 86% of the participants strongly agreed or agreed that the experience using the SIMPLe application was satisfactory whereas only 14% reported being neither satisfied or not. The vast majority (82%) reported that the application was useful and pertinent for the self-management of their condition whereas only one patient disagreed about its utility. The discretion, lack of invasiveness and comfort with its daily usage was high with 92% agreeing or strongly agreeing that the application fulfilled these characteristics. Finally, only 2% of the patients reported having technical difficulties or issues using the application, 98% agreed that it was easy and friendly to use. The most common features suggested were: 1. having the possibility to view a longer timeframe of their mood chart (N=16), 2. medication reminders (N=10), 3. some

kind of reward system if tests were answered (N=8), 4. a possibility to share their mood chart over social networks or email (N=5) and 5. having the option to add personalized questions to the tests (e.g. prodromal symptoms) (N=3).

3.5. Mood state correlations and predictors of retention

SIMPLe 1.0 shows a mood chart according to the daily tests answers of the patient. The daily score represented in the chart is the result of an algorithm, which was tested with experts and patients during the development phase. The main objective of the algorithm is to detect mood changes in terms of a short screening test. The resulting score ranges from −35 to +35, a negative (-) sign indicating predominance of depressive symptoms whereas a positive (+) sign representing predominance of manic symptoms. With the intention to evaluate the convergent validity between the daily test score and standardized clinical mood scale scores of those patients who completed the study, a Pearson correlation analysis was conducted. We found statistically significant correlations between the mean score of the last 7 days (1 week) based on daily tests and the YMRS score ($r=0.561$, $p=0.001$) as well as the HDRS score ($r=-0.359$, $p=0.01$). We considered that calculating a mean score of the daily tests would be the most appropriate approach considering the time evaluated, especially, by the HDRS, which assesses the mood during the last week. The mean average daily test score of the sample was −2 (SD=6.21) suggesting a predominance of depressive symptoms during the participation follow-up period.

Over the course of the study, one hypomanic episode as well as one depressive episode were registered in different patients. However, none were related to the use or misuse of the smartphone application.

We explored potential predictors of discontinuation at 3 months considering baseline sociodemographic and clinical variables. There were no significant differences in terms of age between completers and non-completers (i.e. drop-outs). Exploring clinical variables, we computed a binary logistic regression model ($\chi^2(2)=8.692$, $p=0.01$) explaining a statistically significant percentage of completers. This model explained 29.3% (Nagelkerke R^2) of the variance in the retention and correctly classified 83% of cases. A higher total FAST score ($b=1.12$, $p=0.02$) and more years of smartphone usage ($b=2.02$, $p=0.04$) were the only two variables weakly related to the retention outcome.

4. Discussion

To our knowledge, this is the first study to evaluate the feasibility of mood monitoring and providing personalized psychoeducation in BD through a smartphone application independently of a face-to-face psychoeducational program. The results confirm that this particular intervention is feasible and represent a satisfactory and acceptable instrument for self-management of BD as an add-on to the usual treatment. Furthermore, the ecological momentary assessments embedded in the application, suggested it could be a potential valid tool in mood self-monitoring and may contribute to preventing suicide as has been previously reported by other studies (Thompson et al., 2014; Yang et al., 2015).

Similarly, several studies have previously evaluated the possibility of providing remote psychoeducation programs for BD over diverse internet-supported technologies (Barnes et al., 2014; Lauder et al., 2014; Proudfoot et al., 2012; Todd et al., 2014). Almost all these programs based their interventions on adaptations of adjunctive psychoeducational programs for BD with or without complementary components of cognitive behavioral therapy (Hidalgo-Mazzei et al., 2015a). Due to its wide availability, versatility and flexibility, the World Wide Web (WWW) was the most common platform employed so far by these programs. The vast majority of studies evaluating the aforementioned interventions, reported as good retention rates (ranging from 50% to 80%) as ours and most of them were perceived as useful tools by the patients as well (Barnes et al., 2014; Lauder et al., 2014; Proudfoot et al., 2012; Simon et al., 2011; Todd et al., 2014).

SIMPLe is not the first project using mobile devices to provide personalized psychoeducation messages in BD. At least one other project explored a similar approach integrating both mood monitoring and psychoeducation messages in a mobile platform in order to augment psychoeducation efficacy, albeit as a complement after in-person sessions and not as an independent intervention. The Personalized Real-time Intervention for Bipolar Disorder (PRISM)(Depp et al., 2014) project consisted in daily mood self-monitoring with surveys from a mobile device which at the same time provided personalized coping strategies based on the answers. The authors conducted a single-blind trial to evaluate the feasibility, acceptability and efficacy of the program as an augmentative intervention in the self-management of mood symptoms. Eighty-two patients with BD received four in-person psychoeducation sessions after which they were assigned to one of the two arms for 10 weeks: a PRISM assessment and intervention method using a smartphone or a paper-and-pencil mood monitoring method. The PRISM assessment and intervention method consisted of a web-based questionnaire requested to answer twice a day at customized times and receiving coping strategies responses according to the answers given. Additionally, the user was able to receive graphical feedback of their response through a different smartphone application. The authors found that using the mobile device intervention was not only feasible, with very high retention rates of about 93% at the end of the intervention, but users also reported high levels of acceptability and satisfaction.

In contrast to PRISM, the SIMPLe application was not designed as an augmenting intervention, but a totally independent self-management and straightforward method targeting mainly relapse prevention instead of mood symptoms. Thus, besides the initial explanation from the researcher and eventual emergency notifications, the user has total autonomy with almost none interaction with the healthcare team except for the usual treatment. This, together with the shorter duration of the PRISM trial, could have influenced the lower rates of retention in comparison to PRISM (74% versus 93%). Nevertheless, the retention percentages of our program (74%) seems in line with retention rates obtained by brief group psychoeducation programs (Cardoso et al., 2014; Parikh et al., 2012), and higher than task-intensive web-based psychoeducation programs using a similar timeframe (Depp et al., 2014; Lauder et al., 2014; Meiser et al., 2013; Todd et al., 2012). In addition to the years using a smartphone, which is a reasonable predictor, the retention rates were related neither to sociodemographic variables nor to illness characteristics. In fact, our results suggest that a higher degree of functional impairment predicted the probability of completing the follow-up period. This finding is open to speculation. It might be a greater percentage of individuals on permanent disability leave among patients with a FAST score above 11 (82%), and as a consequence more time available to complete the tests in comparison with those who were actively working. It could also be related to a higher motivation to use the app due to their perceived need for help to manage the illness and its negative impact (Oexle et al., 2015).

Taking into consideration the high drop-out rates of ours in such a short time-frame as well as those of other similar studies, one of the most important challenges of any kind of independent remote or online psychoeducation program is to find new approaches to motivate and engage patients with the intervention in the long term, so as to increase the chances to complete the

program (Hidalgo-Mazzei et al., 2015a). This is not a problem exclusively of psychoeducation programs, since general smartphone applications seem to suffer from similar small retention rates (Statista.com, 2015). Taking this into consideration, we adopted a user-centered design approach, which is gaining increasing consensus in online healthcare programs (Jia et al., 2013; Maher et al., 2015; Roth et al., 2014). Another incipient pathway to explore, based on users feedback and way less evidence-based, is to incorporate game elements in a formal psychoeducation process, something which bears a high risk of trivializing the intervention (Brigham, 2015). Given that our results reveal smartphones most common uses are similar to those of the general population, applying these features seems a possible option.

5. Limitations

Several limitations from both the intervention and the study methodology have to be considered. Taking into account the nature of the intervention, results could have been influenced by the so-called "technological generation gap". However, given the very similar mean ages between participants and non-participants as well as completers and non-completers, this does not seem to have been a crucial issue in our study. In terms of the application, it was only available for Google™'s Android Operating System (OS) smartphones; hence, Apple™'s IPhone operating system (iOS) users as well as individuals with other OS smartphones or mobile phones were excluded. This could represent a sampling bias, since smartphone ownership could be related not only to income status but also sex and education (Verto Analytics Inc, 2015). Similarly, despite using the same OS (i.e. Android™), there are several variations in every version of OS and different devices in which it can be installed. Moreover, the application was compatible with Android 4.0 or above, leaving a small percentage of users with older versions out of the study. These facts could modify the participants' experience of the application and finally contributed to the final sample size. However, among the participants no technical problems with the main features of the application were reported or registered at the server. As it is shown in Fig. 2, the fragmentation between and within OSs is a relevant aspect of providing interventions through mobiles devices, which should be taken into account to enhance generalizability (Hidalgo-Mazzei et al., 2016). Therefore, new versions of the SIMPLe application will be available for the most predominant OSs of the market in order to, at least partially, tackle these specific issues in future clinical trials.

The applications' mood chart score relied on the participants' active information input to calculate the clinical algorithm determining mood states and adapting the psychoeducational messages, therefore whenever not enough information was provided a lack of sensitivity and specificity arose. It is also worth mentioning that the same order of the daily and weekly tests' questions could potentially lead to a learning or acquaintance effect (Weinstein and Roediger, 2012). Furthermore, mood scales were only assessed at the beginning and at the end of the follow-up period, so no in-between study mood variations were computable. However, significant correlations were found between the final mood scales and the screening mood chart implemented at the end of the study. Even so, as demonstrated by other studies, passive behavior information captured from the smartphone usage and sensors could enhance the precision of clinical algorithm and could represent a paradigm shift in mood tracking methods (Faurholt-Jepsen et al., 2015). Moreover, according to our results using ecological momentary assessments, the slight predominance of depressive symptoms among participants is compatible with the current evidence of the high prevalence of inter-episode subthreshold depressive symptoms in BD patients, and allows for a more precise detection of this issue, opening to further characterizations of the bipolar population (Bonnín et al., 2010; De Dios et al., 2012).

Regarding the study design and sample, it is worth mentioning that it only included euthymic BD outpatients, which might limit the real feasibility of the application for hospitalized, unstable patients or patients with other mood problems not diagnosed with BD. Nonetheless, the clinical characteristics of the patients show that regardless of euthymia, participants were very similar to those from pragmatic studies concerning high levels of comorbidity, functional impairment and disability (Parikh et al., 2010). Additionally, participants were being treated according to international guidelines for BD, which included in all the cases pharmacotherapy and in some cases, psychotherapy. The psychotherapy could have included current individual sessions but not group psychoeducation, which might have motivated the use of the application even when neither patients' psychotherapists nor psychiatrists were explicitly informed about their participation. In addition, as a result of the exploratory nature of the study inclusion criteria were broad, thus the sample heterogeneity could have on one hand influenced the results and on the other hand provided a more pragmatic and real-world group of patients (Vieta, 2008). As a final point, due to time and resources constraints, the study was conducted during only 3 months, which is certainly a short time-frame to evaluate the feasibility and satisfaction of an intervention aimed to be finally used during one year, which is the time estimated that the patient would have received at least 70% of the psychoeducation messages covering the different chapters of the original program. However, there is still no consensus on how long these kinds of interventions should be offered (Hidalgo-Mazzei et al., 2015a). In the face of this fact, the intervention's feasibility on the long-run must still be confirmed through a longer one-year study, which is the one of the aims of a future RCT.

6. Conclusions

Despite the aforementioned limitations, SIMPLe 1.0 has proven to be a feasible intervention that, if it proves its prophylactic effects, may extend the options to offer evidence-based psychoeducation for BD regardless of their sex, age or functional status. However, its efficacy and effectiveness as an add-on treatment still needs to be evaluated in randomized controlled clinical trials. Finally, this study is an example of technology use for healthcare improvement. These initiatives may give us more precise, granular and real-time illness behavioral patterns. Data from mobile devices (i.e. smartphones, wearables), coupled with clinical, -omics (genomics, proteomics or metabolomics), and neuroimaging, could bring us one step closer to the new era of 'Big data' which holds the promise of better prediction models, prevention strategies and highly tailored treatments at lower costs in BD (McIntyre et al., 2014; Monteith et al., 2015).

Role of funding source

This project was supported by research grants from the Spanish Ministry of Economy and Competitiveness PI14/00286 and PI15/00588, Instituto de Salud Carlos III, Subdirección General de Evaluación y Fomento de la Investigación; Fondo Europeo de Desarrollo Regional. Unión Europea, "Una manera de hacer Europa" (to FC and JS). Other sources of indirect support are a Río Hortega grant (CM15/00127) from Instituto de Salud Carlos III (to DH), a Beatriu de Pinós grant from Secretaria d' Universitats I Recerca del Departament d'Economia i Coneixement de la Generalitat de Catalunya i del programa COFUND de les Accions Marie Curie del 7è Programa marc de recerca i desenvolupament tecnològic de la Unió Europea (to MR), a research grant from the Spanish Ministry of Economy and Competitiveness (PI12/0091), Instituto de Salud Carlos III, Subdirección General de Evaluación y Fomento de la Investigación (to EV); by the Instituto de Salud Carlos III through the Centro

para la Investigación Biomédica en Red de Salud Mental (CIBERSAM) as well as Secretaria d'Universitats i Recerca del Departament d'Economia i Coneixement (2014_SGR_398). FC is funded by the Spanish Ministry of Economy and Competitiveness, Instituto de Salud Carlos III, through a "Miguel Servet II" postdoctoral contract and by a research grant from the Spanish Ministry of Economy and Competitiveness (PI 12/00910).

Contributors and Acknowledgments

Diego Hidalgo-Mazzei, Ainoa Mateu and Francesc Colom designed the study protocol. Diego Hidalgo-Mazzei, Cristina Varo, María Reinares and Marc Valentí conducted the recruitment and enrollment of the patients. Diego Hidalgo-Mazzei and Caterina del Mar Bonnín conducted the statistical analysis. Diego Hidalgo-Mazzei, María Reinares, Andrea Murru, Ainoa Mateu and Juan Undurraga wrote the first draft of the manuscript. Afterwards, Sergio Strejilevich, José Sánchez-Moreno, Eduard Vieta and, finally, Francesc Colom made further reviews as well as modifications. All co-authors have made substantial contributions and have approved the manuscript submitted.

The authors would like to thank all the beta testers of the SIMPLe application for their kind and permanent collaboration in this project (Daniel Ilzarbe, Jordi Blanch, Iria Grande, Clemente García Rizzo, Francisco Olmedo, Raúl Gutiérrez Segalés, César Escobar-Viera, Raúl Albertini, Iria Domínguez, Brisa Solé, Esther Jiménez, Julian Pessio, Rafael Quinteros). The software development of the application was commissioned to SODEP S.A (Paraguay). The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional guides on the care and use of laboratory animals. The protocol of the project was approved in accordance to the local spanish laws (Ley orgánica de Protección de Datos de Carácter Personal (15/1999)). Additionally, the study protocol was evaluated and approved (Reg. HCB/2014/0403 and HCB/2014/1125) by the Hospital Clinic of Barcelona ethical committee and registered in ClinicalTrials.gov (Identifier: NCT02258711).

Conflict of Interest

DH, AM, MR, EV and FC have designed the SIMPLe smartphone application mentioned in this manuscript. The authors declare no other conflict of interests regarding this manuscript. The authors do not have any current or future economic interest in the SIMPLe application, its use or copyrights.

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