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Design recommendations for harm reduction in drug usage: a redesign study of *Bia* with a user-centered approach

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Abstract mHealth technologies emerged with the potential to revolutionize the way people have access to health-related services and information and have commonly been developed to provide health education and support behavior change. However, many of these applications deliver a negative user experience (UX) as they lack components such as desirable functionalities, interface quality, or usage context adequacy, resulting in a gap in user retention. One mHealth sub-domain that is still not widely explored is the consumption of illicit and licit psychoactive substances, especially related to harm reduction practices. This study presents the redesign process of *Bia*, a mHealth application directed to promote harm reduction practices on drug usage in Brazil. The goal of the redesign was to address the usability and content issues identified by a multidisciplinary evaluation and refine the overall product to enhance the probability of delivering a positive experience for the end-users. For that goal, we employed a user-centered design (UCD) approach that encompassed user research, conceptualization workshops with different stakeholders, and two cycles of prototype design and user evaluation. All steps of the redesign were conducted online. The results show how the outputs of each step contributed to developing *Bia 2.0*, which the final design was analyzed in a preliminary UX evaluation using the User Experience Questionnaire (UEQ) and presented an excellent level of UX. We also highlight our main challenges and delineate some design recommendations based on this redesign case and standardized design recommendations.

Keywords: *User Experience, Usability, mHealth, Harm Reduction, User-Centered Design, User testing*

1 Introduction

The popularization and advance of the internet connection and mobile devices brought many possibilities and opportunities to healthcare, implicating the emergence of a new category of applications called Mobile Health (mHealth). They are depicted as a type of health-related service and information delivered or enhanced through the Internet and digital technologies (Eysenbach, 2001), specifically with the support of mobile devices (e.g., tablets, personal digital assistants, smartphones) (WHO, 2011, p.6).

Around 325 thousand health applications were available in digital stores in 2017 (Research2Guidance, 2017), and this number is expected to rise substantially over the next years (Statista, 2021). Adopted by many countries around the globe, mHealth applications have the potential to deliver health services more broadly by facilitating the communication between health professionals and patients and by engaging patients more actively in their treatment to maintain health care (WHO, 2011). These technologies can enhance healthcare delivery as they are low-cost and affordable (Hoque and Sorwar, 2017), which is especially relevant in low and middle-income countries (Kahn et al., 2010).

Some studies show that mHealth technologies have the capacity to improve patient health and quality of life (e.g., Azevedo et al., 2015; Lozano-Lozano et al., 2019), which can be seen through the development and research of an extensive range of interventions, varying from disease management, treatment, care tools, and many others (WHO, 2011; Marcolino et al., 2018). A common domain where mHealth applications are used is education and behavior change (Labrique et al., 2013; Marcolino et al., 2018), as the enhanced communicability through mobile technology offers "a useful tool to deliver education and improve health-seeking behavior or health-related lifestyle decisions" (Hall et al., 2014, p.3).

Albeit the increasing number of possibilities and opportunities enabled by mHealth applications, the field faces several challenges concerning aspects such as sustaining long-term use, producing standardized quality and efficacy measures, and assuring user data privacy and security (Zhang et al., 2014; McKay et al., 2018; Marcolino et al., 2018). Some of the identified barriers to user retention in this type of application are that they often do not attend to the users' needs and expectations or lack features that motivate continuous usage (IMS, 2015). In a review of behavior change applications by McKay et al. (2018), the authors also identified that there is a lack of verification if the functionalities were adequate for the mobile environment or could be effective upon use. Weaver et al. (2013) evaluated 48 alcohol-related health applications and identified that most of them were considered hard to use. Unfortunately, this is a prevalent concern. The IMS Institute for Healthcare Informatics (2015) analyzed 6998 mHealth applications available at a digital store and identified that only 12% of them concentrated more than 90% of the number of downloads within that category. The Research2Guidance (2018) also consulted 2400 app publishers and identified that only 83% of the applications have less than 10000 active users, of which 46% hardly have active users at all.

Therefore, to improve the health outcomes of those interventions, it is necessary to enhance their access, quality, and experience for the end-users (Labrique et al., 2013), especially considering their actual needs and usage context. Assuring that health-related systems are usable and accessible is also crucial to enable the health intervention to be effective and efficient (Goldberg et al., 2011). Additionally, it is crucial that the public feels stimulated to use the application as an active health-supporting tool. Factors such as having a pleasant aesthetic (Tractinsky et al., 2000), or having its usage perceived by the user as fulfilling for their personal needs (Hassenzahl, 2008) are also very important to the user experience as functioning impeccably only does not guarantee that users will feel captivated by the product (Norman, 2002).

In this sense, the Human-Computer Interaction (HCI) field can contribute to the development of mHealth applications tremendously by providing concepts, techniques, and instruments applicable to evaluation and design processes. One central concern of the HCI field is to deliver digital products with a positive User Experience (UX). UX can be described as " a momentary, primarily evaluative feeling (good-bad) while interacting with a product or service" (Hassenzahl, 2008, p.12) and a consequence of the user's internal state, product characteristics, and interaction context (Hassenzahl, 2018). Previous studies show that when the users' experience with a mHealth technology is perceived as pleasant, simple, and useful, the more likely they will keep intending to use it (Verkasalo et al., 2010; Cho, 2016).

Thus, design decisions that seek to provide a better UX are essential to enhance the probability of a product being actively used by the public. In this context, the cooperation of a multidisciplinary team, the adopted technology, the available resources, an appropriate project design, and the integration with the healthcare system are fundamental aspects to develop an effective application (Aranda-Jan et al., 2014). Some studies demonstrate that employing User-Centered Design (UCD) techniques in health-related systems improves the product's ease of use and enhances user adoption (Russ et al., 2015; Luna et al., 2017a,b), besides reducing development cost from a long-term perspective. The UCD approach is very present within the interaction design field (Sharp et al., 2019), and some of its main principles are prioritizing users needs and goals by including their input throughout an iterative development process that encompasses tasks such as: specifying the users, analyzing their tasks, behaviors, and contexts of use; developing design solutions, and evaluating those solutions (Kikuchi et al., 2010; Sharp et al., 2019).

Despite the challenges and concerns, many institutions and organizations recognize the great potential of mHealth technologies. One prominent advantage of electronic health technology, in general, is the perceived anonymity that can facilitate access to people that fear stigmatization, such as illicit drug users or with substance problems (Postel et al., 2005). Concerning the context of drug usage, some digital interventions focus on prevention, harm reduction, and treatment of substance use. According to Blankers and Mujcic (2017), the majority of digital applications concerning drug users are focused on prevention and treatment, while there is a lack of studies on interventions focused on harm reduction. Aiming to provide a mobile application to promote harm reduction on drug usage in Brazil, Lima (2018) developed *Bia*, a mobile application based on the Behavior Analysis approach and in the Harm Reduction (HR) model. The application's primary goal is threefold: 1) to provide general information about drugs and safer use recommendations, 2) to serve as a mobile health promotion tool focused on harm reduction practices on drug use, and 3) to foster user self-awareness and self-control about the factors that influence their drug consumption behavior (Lima, 2018, p.11).

Before analyzing the efficacy and effectiveness of *Bia*, the application was submitted to a multidisciplinary evaluation that encompassed a usability heuristic evaluation and a content analysis, which counted with a group of HCI researchers and a group of psychologists specialized in Behavior Analysis and HR practices, respectively. The result of the analysis pointed out many usability problems, which, if not appropriately addressed, could affect user-app interaction negatively. Some issues were lack of functionality prioritization, inadequacy to usage contexts, complicated information inputs, and some feature malfunctions (Pinheiro et al., 2020). Additionally, the Psychology judges suggested some adjustments in the application content.

Based on the results, the project team decided to redesign *Bia*. The purpose of this study is to present the redesign process of the application, which encompassed an iterative and user-centered design approach and involved a team of HCI, Psychology, and IT researchers. The redesign aimed to address the identified issues and deliver a product that would better attend to user needs and project requirements within the project agenda and resources. The process included several steps: we conducted user research, a conceptualization workshop with different stakeholders, then translated the suggestions and collected data from the previous steps into a medium-fidelity prototype. The prototype was evaluated with end-users remotely. Based on the results, we developed a high-fidelity prototype. Lastly, we also employed a preliminary UX evaluation with the User Experience Questionnaire (UEQ) to analyze the redesign proposal's overall attractiveness to the users. This study also seeks to provide recommendations and suggestions for designing and improving the UX of applications remotely and for the context of harm reduction on drug usage.

2 Theoretical background

2.1 Harm reduction strategies

The consumption of psychoactive substances has been part of various contexts such as for medical, religious, or recreational purposes since ancient times. One of the existing discussions surrounding recreational drug use is the harmful consequences of the abusive intake of these substances, which is a health and security concern in many countries. The majority of the governments mainly employ prohibitionist and punitive policies against substance use (Machado and Boarini, 2013; Sanchéz-Avilés and Ditrych, 2018). In Brazil, for example, some implications of this approach are the focus on reducing drug production and consumption by criminalizing illicit drug users and dealers and the employment of militarized territorial occupation tactics (Machado and Boarini, 2013; Rodrigues and Labate, 2016). Moreover, abusive drug consumption is perceived as an illness that should be treated or have its symptoms mitigated by medication and abstinence imposition (Rybka et al., 2018).

Albeit the prevalence of the international drug control regime, the statistics show that the demand and supply for both licit and illicit drugs are still very present and even on the rise globally. According to the last World Drug Report (UNODC, 2021, p.19), there was a 22% growth in the number of drug consumers between 2010 and 2019. In 2019, it was estimated that 275 million people between 15-64 years around the world consumed drugs at least once in the year before, and among them, an estimate of over 36 million people suffered from drug disorders.

Regarding this matter, Harm Reduction (HR) represents an alternative strategy. It can be described as "a pragmatic approach to reduce the harmful consequences of drug use and other high-risk activities by incorporating several strategies that cut across the spectrum from safer use to managed use to abstinence" (Marlatt and Witkiewitz, 2010, p.593). The HR model acknowledges that some people do not want to or cannot cease their drug consumption entirely, so it focuses on reducing and avoiding potential harmful consequences from drug consumption by providing a range of health and social services and practices. According to the Harm Reduction International [1] non-governmental organization, some examples of HR practices are supervised drug consumption rooms, needle and syringe programs, non-abstinence-based housing and employment initiatives, drug checking, overdose prevention and reversion, psycho-social support, and drug education.

Several studies analyzed the effectiveness of diverse harm reduction strategies. A longitudinal efficacy study of the School Alcohol Harm Reduction Programme (SHAHRP) on reducing alcohol-related harm in secondary school students conducted by McBride et al. (2004) showed that the intervention participants had safer alcohol-related attitudes compared to those who did not participate. They were also more likely to be non-drinkers or supervised drinkers than students who did not participate in the intervention. Other studies have indicated that syringe programs that provide safe injection facilities are directed to significant reductions in needle sharing and reuse and fatal overdoses (Strathdee and Pollini, 2007; Kerr et al., 2006). A systematic review with 47 studies about the outcomes of supervised drug consumption facilities (SCFs) also revealed that these establishments meet their primary public health goals of reducing harm, connecting drug users to addiction treatment and other health services, and reducing public order and safety problems related to drug injection use (Kennedy et al., 2017).

Although many governments advocate for abstinence-only programs (Harm Reduction International, 2020), studies show that harm reduction strategies bring explicit benefits for society. Nevertheless, according to the last Global State of Harm Reduction report (2020, p.18) many countries does not employ such strategies, and even in the places that have HR programs available, there is still a gap in coverage and quality of HR services, as well as lack of access of those services due to geographical gaps and uneven distribution of services. Thus, continuous research towards optimizing the efficacy and applicability of those practices is needed, and further discussion about adopting HR interventions.

[1] See `https://www.hri.global/what-is-harm-reduction`

2.2 Usability and User Experience (UX)

In a competitive market of technological solutions, providing a positive user experience also became a decisive and differential factor for the public (Djamasbi et al., 2014). When referring to user experience, there are many different conceptual viewpoints within the HCI community (e.g. ISO, 2010; Hassenzahl and Tractinsky, 2006; Desmet and Hekkert, 2007) but they all relate UX with usability at some point, which is why it is necessary to look at the concept of usability before grasping the roots of UX (Glanznig, 2012).

Usability has been a central concept in HCI. It can be depicted as the quality in which a system can attend to users' needs (Nielsen, 1994) and is comprised of five main components that address how efficient, how memorable, how satisfying, how easy to learn, and error-proof a system is. Another similar definition is from ISO (2010), where usability is the extent to which the targeted users can reach their goals through the product with efficiency, efficacy, and satisfaction in a specific context of use. Thus, according to (Glanznig, 2012, p.236), usability accesses efficiency and effectiveness problems by measurable factors such as error rates and task completion times. The author also mentions that satisfaction mainly was traditionally seen as "a mere add-on, a nice-to-have feature" and is "approached with thinking aloud techniques and questionnaires."

However, due to the changes in technology usage contexts and paradigms over the years, a necessity of an expanded concept of usability emerged as system usefulness only was not enough to please users (Tractinsky et al., 2000; Norman, 2002). Thus, the "satisfaction" part of usability gained more focus: more studies were conducted regarding the role of subjective factors such as emotion and aesthetics in the perceived quality of interactive systems (e.g. Hassenzahl et al., 2000; Hassenzahl, 2001; Tractinsky et al., 2000). Moreover, the term "user experience" came up as a distinct concept (Vermeeren et al., 2010; ISO, 2010; Glanznig, 2012).

One of the existing theoretical models of UX is the hedonic-pragmatic model by Hassenzahl (2008). In this model, all interactive products have two types of quality that are perceived independently by the users: the pragmatic (i.e., instrumental) quality and the hedonic quality (Hassenzahl, 2001, 2008). The pragmatic quality is related to utility and usability (i.e., the *do-goals*), which in this case, are the system's attributed functionality and its capacity to access the assigned functionalities, respectively. On the other hand, the hedonic quality encompasses the other experience aspects that are focused on users' psychological well-being and *be-goals*. The hedonic quality highlights three aspects: stimulation (e.g., feeling of personal growth, novelty, and opportunity through usage), identification (with the products' evoked character), and evocation (memories and symbols generated through usage). To Hassenzahl (2018), the perception of these two qualities through interaction results in emotional responses - and the more positive these responses are, the greater is the product's perceived attractiveness.

One of the implications of this model is that the different perceptions of both attributes result in distinct impressions of the product's attributes (Hassenzahl, 2018). Studies demonstrate that, in some contexts, products with higher hedonic and lower pragmatic quality result in more positive affective experiences than products with higher pragmatic and lower hedonic quality (e.g. Gross and Bongartz, 2012; Lee et al., 2011). This kind of evidence reinforces the relevance of non-instrumental factors to user experience. Nevertheless, the pragmatic quality should not be disregarded as it also implicates increased user trust and user satisfaction and, consequently, increased customer loyalty with certain products (Flavián et al., 2006). In more complex cases such as in healthcare scenarios, usability (i.e., instrumental) problems can even bring negative consequences to user safety, such as leading to wrong decisions that may harm patients (e.g. Horsky et al., 2005a,b). Hence, the ideal is for a product is to have strong hedonic and pragmatic attributes (Hassenzahl, 2018).

In this regard, design decisions focused on improving the hedonic and pragmatic aspects are essential to product acceptance and extended use. One essential design method is conducting user evaluations, where commonly include a range of methods such as questionnaires, psychometric tests, regulated interactions, semi-structured interviews, and task performance logs (Pettersson et al., 2018). It is also important to follow interface design conventions. There are specific design conventions and evaluation guidelines when addressing UX in mobile contexts, as mobile devices often have small screens and limited interaction space. Some important aspects to consider are the size of tap-areas, different controls, legibility, self-evident navigation, and feature prioritization within the screen constraints (Sharp et al., 2019, p.221).

2.3 UX evaluation of mHealth technologies

UX evaluation plays an essential role in the design process as it enables designers to check whether a product is acceptable or not for the intended public, and it may provide valuable data to improve the evaluated product's design (Sharp et al., 2019, p.496). A range of instruments and methods have been applied concerning the UX assessment in terms of hedonic and pragmatic qualities. According to a review conducted by Diefenbach et al. (2014), the majority of studies have employed numerical scales to assess the hedonic quality, which was standardized questionnaires or single items from them, or self-developed scales. As for the assessment of the pragmatic quality, it is related to manipulation of artifacts and is directly attributed to usability (Hassenzahl, 2018). According to a systematic mapping conducted by (Paz and Pow-Sang, 2016), the most commonly used usability evaluation methods are surveys and questionnaires, user testing, heuristic evaluation, and interview. User testing usually involves observing a representative sample of users interact with the software by following pre-defined tasks.

Many studies debate how and what to apply when conducting UX evaluations under distinct theoretical backgrounds, but it is observed that using a triangulation approach is a widespread practice (Pettersson et al., 2018). In this approach, different methods and techniques are employed to evaluate the users' experience when interacting with a prototype or final product. According to Pettersson et al. (2018) review, the main combinations are of self-developed questionnaires with semi-structured interviews, activity logging, and standardized questionnaires. As for the motivation for adopting a triangulation approach, the Pettersson et al. (2018) identified that the main reasons were to gather deeper insights and to comprehend the results of other applied methods better.

Concerning HCI evaluation of mHealth applications, a review of 22 studies by Zapata et al. (2015) showed that questionnaires, interviews, activity logs, and think-aloud methods are also commonly used. Nevertheless, there is no consensus on which evaluation approach is the most efficient as all methods have their pros, cons, and other specific factors that are related to the specific context of the system and targeted public (Jake-Schoffman et al., 2017). Thus, it is essential to consider those factors and count with HCI professionals when planning an evaluation of a mHealth application.

3 Related work

Recently, HR programs have been employed through information technology and mobile application development. According to the European Monitoring Centre for Drugs and Drug Addiction report (2017, p.28), the opportunities in the field include "the use of e-health applications to deliver brief interventions and recovery support more widely, and the use of Behavior insights to develop more effective programmes.". In this section, we point out some mobile applications and redesign studies that are related to our work.

3.1 Mobile applications for harm reduction

According to the World Health Organization (2018), some of the significant ways that mHealth technologies are increasing access to quality health services and enhancing patient, family, and community engagement. According to Research2Guidance (2017) report, around 325 thousand of mHealth applications were available in digital stores in 2017 - within this group, 78 thousand were released between 2016 and 2017. Some of the types of health services available through mHealth applications are illness detection, health promotion, prevention of illness worsening, decision support systems, management and surveillance of chronic conditions, and many more (WHO, 2011).

When searching for "Harm Reduction" in mobile application stores, many of the results were related to sobriety counter apps, meditation, self-harm, and mental health systems. Only a few systems focused on harm reduction in drug use are available, and mainly of them are in English. As for Brazilian Portuguese harm reduction applications, we found the **"Redução de Danos"** and **"Projeto Fique Legal"** but both lack periodical updates and showed malfunction. Nevertheless, we found some applications related to *Bia*'s features and goals and highlight them below.

In 2016, Philipp Kreicarek developed and launched the mobile application called **KnowDrugs** [2], which is focused on displaying information about recent pill and drug testing warnings according to the user's location; providing information on effects, characteristics, and safer use of psychoactive substances; and provides a list of recommendations for emergency help. The main goal of supporting drug users with re-

[2]Available in: `https://knowdrugs.app/en/`

liable information to reduce harm is similar to *Bia*'s, and the application provides more detailed data for a more extensive range of psychoactive substances, but it does not offer a feature for consumption self-monitoring.

Similar to the KnowDrugs app, the **TripApp** mobile application [3] main features include drug testing warnings, dosage checker, and other information about psychoactive drugs, legislation, recommendations, and nearby services related to safer drug use. The application was released at the end of 2019 and brought by three non-governmental organizations: *Youth Organisations for Drug Action*, *NEW Net*, and *Help Not Harm*. Despite being available in Portuguese, the location filter options are currently restricted to European countries, and it is also more focused on being a guide for safer drug use practices.

The **Dose - Drug Journal** [4] is a mobile calendar focused on tracking down substance usage, either vitamins, supplements, medication, or other licit/illicit psychoactive drugs. The user can set different notification goals such as reducing dosage and medication tracking, and the application also provides a dashboard with the consumption stats. The dashboard and calendar features are somewhat similar to *Bia*, but Dose's entry form is focused on the consumption dosage while *Bia*'s form requires other information such as physical and emotional moods. Furthermore, it does not provide specific recommendations or information about each substance, but it has a section dedicated to bad trips.

3.2 mHealth redesign studies

We also highlight a few examples of studies focused on redesigning and evaluating health-related applications. Nurhudatiana and Seo (2020) conducted a heuristic evaluation based on Nielsen's ten usability heuristics (Nielsen, 1994) on *Halodoc*, an application that connects patients with health services such as licensed doctors and clinical laboratories. After the evaluation, the authors redesigned the user interface (UI) to address the reported usability problems and evaluated the redesign to assess its usability quality. Later, Kushendriawan et al. (2021) published about the evaluation of Halodoc using usability testing (i.e., user testing) and the UEQ (Laugwitz et al., 2008). The latter study also provides recommendations and suggestions to improve the UI and reinforces the relevance of involving end-users in evaluations to deliver a product with an enhanced user experience.

Similarly, Dexheimer et al. (2017) designed and evaluated the web-based application called Self-Monitoring Activity-Restriction and Relaxation Treatment (SMART), which focuses on providing recommendations and guidance in reducing subsequent sequelae to young patients with mild traumatic brain injury. The authors employed user testings with questionnaires to assess usability and modify the application before further study and implementation. Then, the application was redesigned and re-evaluated before undergoing efficacy testing (Schmidt et al., 2020). The used methods to evaluate the usability were user testings with participants and the standardized System Usability Scale (SUS) (Brooke et al., 1996). The results showed that the program was highly usable and pertinent to the experiences of the targeted public but gave directions for further improvements that led to a more "robust and usable user experience."

Although the mentioned studies present products directed to different health issues and users, they are similar to ours in depicting iterative design processes of mHealth applications. We also integrated end-users through user testings and questionnaires and delineated the study's specific context's main challenges, recommendations, and limitations.

4 Understanding the study object

Bia was developed as a health-promoting tool that facilitates access to relevant and trustworthy information related to HR practices as there is a lack of applications focused on this topic in Brazil. The tool is also supported by the behavior analysis approach to "present information about the variables of drug consumption behavior, especially concerning the frequency of the registered behaviors" (Lima, 2018, p.41) by enabling users to register and monitor their drug use experience. Thus, *Bia* also aims to promote self-awareness and self-control of users about their relationship with drugs.

This section briefly describes the *Bia*'s preliminary version development process and features to contextualize this product's (re)design process and explain our participation as HCI researchers.

4.1 The preliminary version of *Bia*

Bia's first version was developed by a group of Psychology, Social communication, and Software engineering students and professors from the Federal University of Ceará. The development process followed the Contextualized Instructional Design (CID) model (Filatro and Piconez, 2004), which is based on the Systematic Instructional Design (SID) model (Dick et al., 2005) and encompasses the steps of Analysis, Design, Development, Implementation, and evaluation. How each step was carried on is summarized below:

The team conducted a target-public characterization and bibliographic research in the first step of **Analysis**, and also defined the application's educational objectives, content, and technological structure. Then, they proceeded to the **Design** step, where they planned and produced the application's interface and content. The system typography, visual identity, screens, and media content were also delineated.

The third step of **Development** compromised the application's software development and was proceeded with the Android Studio Integrated Development Environment (IDE). Lastly, for the **Implementation and Evaluation** step, the team configured the download platform of *Bia 1.0*. The resulting preliminary version of the application presented six main sections:

- **Drogapedia**: Displays a directory presenting textual information about some substances' effects, types of usage, and other curiosities (Figure 1).
- **Diary**: Presents a logbook for registering and consulting the details about the user's experience before, dur-

[3] Available in: `https://tripapp.org`.
[4] Available in: `https://doseapp.io`.

ing, and after each substance use. It also displays a dashboard with an overview of the user's registered consumption.

- **Bad**: A section with general recommendations in case of emergencies and discomfort after substance use.
- **Chill out**: A selection of different media tools to relax and entertain. It stores musical playlists, image galleries, recommendations, and a memo pad to register ideas.
- **Reducing harm**: A section with general information about HR practices and specific drug recommendations for safer use.
- **Profile**: A section focused on setting the user's personal information such as the nickname, gender, and age. It also enables users to access and register emergency telephone numbers and provides a list of nearby health services stations based on the user's GPS localization.

Figure 1. Home screen and initial screen of the Drogapedia section of *Bia 1.0* (Lima, 2018)

4.2 The redesign context

The project team submitted *Bia* to a multidisciplinary evaluation regarding its content, didactic resources, and interface as part of the CID process. In *Bia*'s case, a group of three psychologists specializing in HR and Behavior Analysis was responsible for analyzing the application's content and didactic resources. As for the interface analysis, the project team invited us - a group of HCI practitioners - to conduct a usability inspection. This approach represented the introduction of a different perspective on a project that did not have any designers or HCI practitioners involved until then.

These evaluations were conducted during the COVID-19 pandemic in 2020 when the public health institutions mainly advised social distancing measures to inhibit the spread of the virus (ECDC, 2020). Thus, we decided to conduct a heuristic evaluation since it does not require the involvement of end-users, and it could be conducted online without significant constraints. This decision was aligned with the project's short timetable and resulted in a set of identified usability problems and redesign suggestions, which are better described in the published work of Pinheiro et al. (2020). The synthesis of the multidisciplinary evaluation suggested that some content and interface adjustments should be made to improve the potential of *Bia* to bring a positive experience to the targeted public. Some of the identified problems were that the application's content was too formal and dense, there were also significant issues on the internal design consistency, and the overall data input format was overly complex.

Due to the complexity and amount of suggested adjustments, the group responsible for the *Bia* project decided to redesign and develop a second version of *Bia* from scratch. Besides the amount of refinements, the fact that the project group was composed almost entirely of new members also endorsed the redevelopment the application. The goal was to address the identified issues and to enhance the pragmatic and hedonic qualities of the product, which can improve the chances of providing a positive user experience (Hassenzahl, 2018). This time, they also counted with a team of HCI practitioners and researchers to collaborate to redesign *Bia 2.0*, which process is the main focus of this work.

After joining the project, we proposed a different approach for the design process: the User-Centered Design (UCD). Another decision was to scope the redesign to a Minimum Viable Product (MVP) (Ries, 2011) as the project had resources and time limitations. Thus, this work focuses on presenting this process of redesigning *Bia*'s interface and discussing the findings and recommendations for harm reduction and overall health application designers.

4.3 Ethical issues

This project was submitted to the Ethics in Research Committee of the Federal University of Ceará (UFC) and can be tracked by the 52341721.5.0000.5054 number certificate, and its approval statement number is 5.068.684. We seek to respect the four relevant aspects to HCI research involving people (Leitão and Romão-Dias, 2003), which were: informed consent of subjects, the protection of their anonymity, and the protection of vulnerable groups such as minors and disabled people. We also seek to guarantee the well-being of the participants by conducting remote surveys and user testings to respect the social distancing measures and avoid COVID-19 contamination. All participants in the design process voluntarily agreed to participate through online recruitment forms and digital consent forms.

5 Methodology

This section describes the redesign process of *Bia* from the multidisciplinary evaluation step onward, as it is the point where the HCI team integrated the project, and it provided crucial recommendations to the following redesign steps. The project team encompassed three sub-teams: Psychology, HCI, and Development teams.

The redesign process comprised seven phases: i) multidisciplinary evaluation, ii) user research, iii) conceptualization, iv) design of the medium-fidelity prototype, v) user testing with the medium-fidelity prototype, vi) design of the high-fidelity prototype, and vii) preliminary UX evaluation of the high-fidelity prototype. Figure 2 summarizes the project's design and redesign phases and their respective outputs.

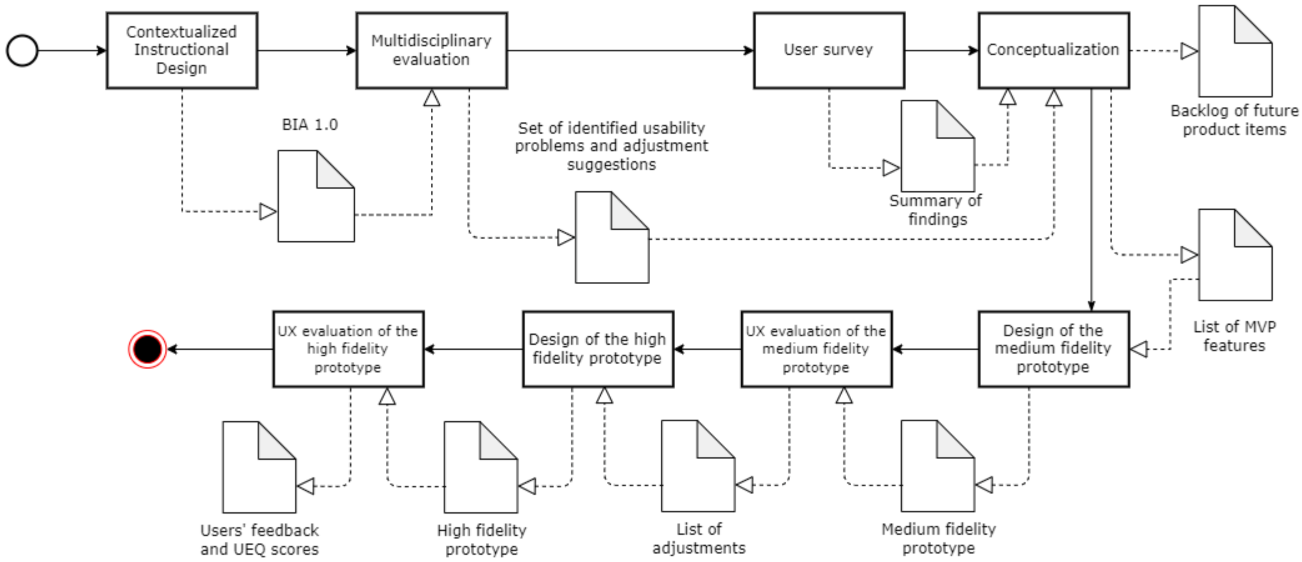

Figure 2. Steps, inputs and outputs of *Bia* redesign process.

5.1 Multidisciplinary evaluation

The goal was to verify if the content and employed strategies of the application were adequate for the targeted public and product's agenda and evaluate the application's usability. This phase also focused on mapping potential problems and adjustments of *Bia* for further refinements before investigating the efficacy of the application with real users. This phase was recommended by the CID model and comprised two approaches: a heuristic evaluation and an analysis of the overall functionalities and information.

5.1.1 Participants

Two teams of evaluators participated in this step. Three Harm Reduction and Behavior Analysis specialists from the Psychosocial Care Center of Fortaleza (CAPS) conducted the analysis of the application's content and functionalities. In the second approach, three HCI researchers from the Federal University of Ceara with different experience levels (2 to 12 years) conducted the usability inspection.

5.1.2 Material

The psychology team prepared a questionnaire to explore how well each application functionality accomplished its proposal and how they were aligned with the HR model through a five-point Likert scale varying from "1- Unsatisfying" to "5-Satisfying".

The HCI team developed a spreadsheet template for the heuristic evaluation. The spreadsheet had one page for each application section, each presenting a set of suggested tasks and requiring the following inputs: where the problem was identified, which heuristic it is related to, problem description, severity level, and related task.

5.1.3 Procedure

Analysis of the information: The judges had to fill out a questionnaire created by the psychology team, which was based on the Nielsen heuristics (Nielsen, 1994). The items explore how well each application functionality accomplished its proposal and how they were aligned with the HR model through a five-point Likert scale varying from "1- Unsatisfying" to "5-Satisfying" downloaded the app. The evaluators also provided additional suggestions and observations about each application section. After the three analyses, the psychology team compiled the responses from the specialists and highlighted the most recurrent issues to guide possible adjustments that were later presented to the other teams.

Heuristic evaluation: The HCI team decided to apply a heuristic evaluation after considering the project's financial, time, and human resources available. First, two researchers selected and compared different sets of usability heuristics with Nielsen (1994) heuristics to identify equivalent and additional evaluation aspects that would encompass the product's main characteristics. The final set comprised three groups of heuristics: one group of 13 heuristics directed to mobile applications (Joyce and Lilley, 2014), and 14 heuristics selected from two sets (i.e. Monkman et al., 2015; Inostroza et al., 2016) directed to health applications.

After the selection, the judges established a protocol specifying the inspection's tasks and time limit then conducted the inspections individually. Subsequently, the HCI researchers analyzed the recorded problems and discussed the findings together to remove overlapping issues and divergent heuristics or severity categorizations. The result was a document with 98 identified problems and a summary of the most addressed heuristics. The team developed some low-fidelity prototypes screens to illustrate the suggestions better for some of the main issues of the application and presented the findings to the project team. Further details of the heuristics evaluation process are published in Pinheiro et al. (2020) work.

The synthesis of those two evaluations indicated that several adjustments in the overall product should be made in the application, especially concerning instrumental aspects (i.e., usability). Elements such as content, navigation, information architecture, design theme, and layout had to be improved to enhance the product's probability of providing a positive experience for the users. Besides the amount and complexity of things to be refined, the project group was primarily composed of new members so it was decided that it would be better to redesign a new version of *Bia*. Thus, the resulted set of suggestions and identified problems were used as a reference for the next steps of the redesign process.

5.2 User research

Following the UCD principle of involving users in the conception phase of the application, we decided to take a step back before redesigning a new interface to get more familiarized with the targeted public preferences and different profiles. For that, we decided to conduct an online user survey with questions related to drug consumption and follow-up practices, and topics of interest.

5.2.1 Participants

343 people participated in this step, of which 313 were considered valid responses. Our selection criterion was that the participant should be above 18 years old and be a psychoactive drug user.

5.2.2 Material

The survey was conducted via Google Forms and was comprised of 25 questions divided into three sections. The first section had nine questions focused on gathering quantitative information about some aspects of drug consumption behavior, such as which circumstances and how the targeted public usually searches about psychoactive substances; which topics related to drug consumption are they more interested in; and how often do they use drugs and how do they keep track of their consumption.

The following section of the survey investigated how important the participants considered a set of ten features and topics related to drug use with a 5-point Likert scale. The third and last section had six questions focused on general sociodemographic information.

5.2.3 Procedure

This survey was announced through social media and was directed to people who were above 18 years old and consume psychoactive drugs or used to do so.

We gathered a total of 313 valid responses, of which all participants were above 18 years old and had voluntarily agreed to participate in the survey. This step's output helped us know the targeted public's most preferred features and topics and enabled us to build four user profiles. With the survey, we could also verify the interest in some of the already stipulated features and additional ones, contributing to the Conceptualization step.

5.3 Conceptualization

The goal of the Conceptualization step was to review, brainstorm, and redefine the functionalities and content of the new version while considering the technical possibilities, the primary application goals, the recommendations from the multidisciplinary evaluation, and the user research findings. This step consisted of one online ideation workshop and prioritization exercise, and the outcome guided the design process as we set the list of functionalities that the new version of *Bia* should have.

5.3.1 Participants

Six participants from all project teams participated in this phase: two people from the Development team, two people from the Psychology team, and two people from the Design/HCI team. All participants were graduate students of the Federal University of Ceara.

5.3.2 Procedure

The ideation workshop focused on co-creating new feature ideas with the project stakeholders to have a more holistic perspective of the new version from the beginning of the redesign process. Everyone was informed about the findings from the multidisciplinary evaluation and user research. Before the workshop, we prepared a document explaining the preparations and procedures they should expect as most participants were not acquainted with the upcoming activity.

The workshop was divided into three parts, of which two were conducted synchronously through video-conferencing. We reviewed the workshop goals and procedures in the first meeting and presented the targeted public profiles. Then, we conducted two structured brainstorming sessions based on the 4x4x4 activity [5], which establishes three rounds of brainstorming with the limit of 4 minutes focused on rapidly listing ideas to solve a predefined challenge. The challenges were presented in the form of questions, which were *"how can we engage our users to register their drug consumption in the application?"* and *"how can we provide more attractive content so that the targeted public will actively use the application as a consultation tool?"*.

Each brainstorming session comprised three rounds but with an extended time duration of 4, 8, and 8 minutes, respectively. In the first round, all participants wrote their ideas individually on an online whiteboard within 4 minutes. Then, we split the party into two groups composed of one member of the HCI, the Psychology, and the Development team to discuss their ideas and formulate four different proposals within 8 minutes. Lastly, everyone discussed and formulated four additional proposals based on the previous ideas within 8 minutes.

Then, we compiled the eight ideas resulting from the brainstorming sessions in an online document for the second part of the ideation workshop, conducted asynchronously. For this part, the team focused on adding more details to each proposal until the next synchronous meeting. Then, we joined an

[5] Available in: `https://www.invisionapp.com/inside-design/design-thinking-redesign/`

online meeting to review the suggestions together and define a set of product backlog items. We wrote down the resulting ideas and the application's core features in a spreadsheet for documentation. Many of those features were adjusted to follow the new requirements suggested by the psychologists' content analysis.

After finishing the ideation workshop, we scheduled another online meeting to delineate the features of the Minimum Viable Product (MVP) version *Bia 2.0*. This meeting was crucial to scope down what would be viable considering the project resource limitations and schedule. Hence, we employed two prioritization exercises: Caroli (2018) technical, user experience, and business review and the MoSCoW prioritization technique (Stapleton, 1997).

In the review, the team assigned 1 to 3 points regarding effort, business value, and user experience value of each application feature listed in the spreadsheet. Next, we classified each feature according to the MoSCoW prioritization criteria: M standing for "MUST-have" features that otherwise could lead to project failure, S for "SHOULD-have" features, important features that could be incorporated later on; "COULD-have" functionalities that may benefit the project but are not essential; and "WON'T-have," which are expected requirements that will not have to be incorporated in the current project. Then, we had decided to build only the 22 "MUST-have" features and sub-features for the MVP, while the others were archived to future versions.

5.4 Designing the medium-fidelity prototype

After redefining the application requirements list and primary information architecture, we proceeded to work on the new User Interface (UI) of *Bia*. The goal was to design a medium-fidelity prototype that portrayed the new version layout, navigation, and interactions. A medium-fidelity prototype simulates a system, and it is somewhat similar to the final user interface and navigation. It is "fairly detailed and complete, but objects are presented in schematic or approximate form" and has the advantage of providing sufficient detail for user testings with "much lower cost and time as compared to high fidelity" (Engelberg and Seffah, 2002, p.204). After creating the prototype, we planned to test it with real users before building the high-fidelity version.

Our design decisions sought to address the usability problems identified in the heuristic evaluation of the preliminary version while also providing a satisfying set of features that attends to the users' needs. Therefore, we structured the information architecture of the new version of the application based on the "MUST-have" features selected in the Conceptualization phase. We defined how the content would be divided and how the navigation between the sections and screens would work based on context and relevance for both users and project goals, then documented through diagrams. After this initial mapping, we proceeded to design the user interface using the Adobe XD prototyping tool. We used some low-fidelity screens previously designed for the heuristic evaluation hand-off as references. We decided to adopt some of the components and design patterns established by Material Design for Android [6] as it would be more familiar to the final users. Additionally, we searched for similar products available in the Google Play Store (e.g., tracking, diary, meditation, health apps) for additional reference. The result was a fully interactive prototype comprised mainly of grayscale colors and one accent color as our primary focus was to set an initial proposal of the layout and navigation of *Bia 2.0*.

5.5 UX evaluation of the medium-fidelity prototype

After developing the medium-fidelity prototype of *Bia 2.0*, we conducted online tests to evaluate the user experience of potential users when interacting with our initial redesign proposal. The test would also enable us to identify possible problems that should be solved during the high-fidelity prototype development process. We employed different activities and materials in the evaluation to analyze the prototype's pragmatic and hedonic aspects.

5.5.1 Participants

Nine participants were recruited through an online questionnaire promoted through social media. The requirements were that the participant should be above 18 years old, be an undergraduate student or have a college degree, and consume illicit or licit psychoactive drugs. They should also have a stable Internet connection, a smartphone with the Android system, and a desktop computer to participate.

5.5.2 Material

An online formulary with 20 items was used to recruit the evaluation participants. The form collected information about the users' psychoactive substance consumption, sociodemographic information, and contact information.

In the user evaluation, we used an interactive prototype created on Adobe XD platform to present the redesign proposal and collect user feedback. We defined 11 tasks for users to perform. After each task, we applied the Self Assessment Manikin (SAM) (Bradley and Lang, 1994) to get quantitative feedback on the hedonic aspect of emotion as it accesses three components of users' affective responses: pleasure, dominance, and arousal, each through a 9-point pictorial scale.

After the regulated interaction, we employed the Net Promoter Score (NPS) (Reichheld, 2003) to verify the overall satisfaction of the participants after interacting with the prototype. The NPS is a 10-point Likert scale that estimates how likely they would recommend the product to friends and colleagues.

Lastly, we employed an online sociodemographic form that included the Brazilian Economic Classification Criteria questionnaire (APEB, 2019) so that we could have more detailed input about the sample profile.

[6] Available in: `https://material.io/components`

5.5.3 Procedure

First, we released an online application form through social media to get volunteers interested in the evaluation. After the screening, we contacted the volunteers, scheduled the individual experiment, and sent a summary of how the evaluation would proceed.

Each experiment took around 35 to 50 minutes. The experiment was conducted by one researcher via Zoom and Google Meet platforms and was divided into four moments: i) resume of the evaluation process and signing an online consent form; ii) regulated interaction with the prototype and the utilization of SAM (Bradley and Lang, 1994); iii) post-interaction interview, and iv) administration of the NPS (Reichheld, 2003) and a sociodemographic questionnaire.

In the first moment of the experiment, the researcher reviewed the evaluation steps and asked about the participants' consent to record the meeting and use the collected data in this work. Then, the volunteers were asked to share the video of their smartphone screen so that the researcher could observe how they interacted with the prototype. They were advised to interact with the prototype through their smartphones and then fill out the evaluation forms through a desktop computer for their convenience.

Next, the participants had to perform 11 predefined tasks with the prototype to evaluate the pragmatic aspects of the initial proposal of *Bia 2.0* for the regulated interaction step. The researcher disclaimed that the prototype was still on medium-fidelity, focusing on testing the application's overall navigation, information architecture, and concept. Thus, the prototype was mainly composed of grayscale colors and placeholder images. Another disclaimer was that the prototype had some technical limitations, so some mechanics (e.g., word typing and more complex animations) would not work the way they expected. During the tasks, the participant was encouraged to follow the think-aloud protocol (Van Someren et al., 1994), which consists of speaking aloud their rationale and impressions while performing the activities. After performing each task, the participants filled out the SAM (Bradley and Lang, 1994) scales through an online form.

After performing the task list, the researcher conducted a semi-structured interview with nine questions with the participants about their comprehension of the primary functionalities of the app and also about their perception about possible real-life contexts of use with *Bia* to consult whether the proposed features would support the primary needs of the targeted public. Suggestions from the volunteers were welcome, and other observations made by the conductor were also discussed to comprehend better the impressions, doubts, and difficulties that the participants had encountered during the regulated interaction. Lastly, we applied the Net Promoter Score (NPS) (Reichheld, 2003) and the online sociodemographic form.

The findings enabled us to identify interaction and interface problems that were overlooked during the design process. Although some problems were identified, the users' general feedback towards the application was positive, which showed that we were going in the right direction. The participants also gave some feature suggestions, which were presented along with the other findings to the project team.

5.6 Designing the high-fidelity prototype

The focus of this step was to develop a "lifelike simulation of the final product with refined graphic design" (Engelberg and Seffah, 2002, p.204) based on what has been collected and decided on the redesign process so far. The high-fidelity would be used for a preliminary UX evaluation with users and then used as a reference for the Development team.

After the analysis of the user testing collected information, we presented a summary of the results from the UX evaluation to the other members of the project. In this meeting, we discussed which identified problems and suggestions we should address in the MVP version as we had to consider the project's agenda and technical limitations, and the proposal requirements. This consultation led us to review the application information architecture and its navigation and layout. After readjusting some application requirements, the HCI team proceeded to design the high-fidelity prototype using the Figma prototyping tool.

We focused on correcting the interface issues we identified during the UX evaluation. Besides that, we also refined the visual identity of the application by testing and defining the color palette, typography, iconography, and illustration styles. For that, we used free-to-use libraries such as Storyset, Unsplash, and Flaticon. The result was a high-fidelity prototype of *Bia 2.0* with its final visual interface identity and set of features.

5.7 Preliminary UX evaluation of the high-fidelity prototype

5.7.1 Participants

We recruited 55 participants for this evaluation. The targeted participants were also young adults that were casual drug consumers, which were picked from an online forms that was promoted through social media.

5.7.2 Material and procedure

Due to project schedule delays, conducting a second round of user testings was not possible until the development of this paper. Thus, we decided to employ a preliminary consultation through an online survey asynchronously to evaluate how attractive *Bia 2.0* is to the targeted users in a first impression, and if it has potential to provide a positive user experience. The online survey was divided into five main sections: i) introduction of the study purposes and requirements, ii) sociodemographic questionnaire, iii) questions about their drug consumption and follow-up practices, iv) presentation of the application's main features screens and hypothetical scenarios, and v) 26 items from the Portuguese version of the User Experience Questionnaire (UEQ) (Cota et al., 2014) and an optional field for comments and suggestions.

The first three sections filtered out underage participants and non-drug consumers. We used the same drug use-related questions of the previous UX evaluation recruitment survey (Section 5.5) and some of the sociodemographic items. Participants from the UX evaluation of the medium-fidelity prototype were allowed to participate in the survey.

The fourth section of the forms presented the *Bia*'s main features screens and respective descriptions. The participants were instructed to carefully observe and analyze the application screens to answer the subsequent questions. Next, we presented two hypothetical scenarios involving two of the main activities of the application: registering the experience of substance use and accessing the consumption statistics. The purpose was to let people observe the interface then wonder how they would interact with it to accomplish the task mentioned in the hypothetical scenario. After each scenario description, we displayed a video that showed how the interaction worked.

In the last section, we applied the UEQ (Laugwitz et al., 2008). This questionnaire accesses product attractiveness through the pragmatic aspects of efficiency, dependability, and perspicuity and the hedonic aspects of stimulation and novelty. These six aspects are accessed by 26 scales of semantic difference and had their scores calculated by a standardized spreadsheet provided by the authors (i.e., Schrepp et al. (2014). Besides the UEQ, we also provided an open field for additional comments and suggestions.

The formulary collected a total of 49 valid responses. The UEQ scores were calculated through the data analysis tool [7], which automatically calculates the scores of the pragmatic and hedonic qualities and their respective scales. The UEQ scale ranges from -3 (horribly bad) to +3 (extremely good). According to (Schrepp, 2015, p.5), the standard interpretation values of UEQ indicate that values between -0.8 and 0.8 represent a neutral evaluation of the corresponding scale, values less than -0.8 represent a negative evaluation, and more than 0.8 represent a positive evaluation. The results indicated that the product presented excellent scores in all sub-scales, thus, indicating that Bia 2.0 presented positive attractiveness. After this step, the new version of the application proceeded to be implemented by the development team.

6 Results

In this section, we present the results of each redesign step from the multidisciplinary evaluation until the UX evaluation of the high-fidelity prototype of *Bia 2.0*.

6.1 Multidisciplinary evaluation

The results from both analysis are summarized below to contextualize how the findings impacted the following steps of the design process.

Analysis of the information. The final analysis indicated that *Bia*'s features were aligned with the product proposal as all functions were evaluated as 3-Regular to 5-Satisfying. Nevertheless, the judges suggested some refinements, such as adapting the content to the targeted public and inserting more information about the harm reduction model. The judges also identified that the content structure of the substances in the Drogapedia section was not standardized as some drugs had more information than others and suggested adding more content about the behavior and psycho-social effects of each substance. Some functionality malfunctions were also reported.

Heuristic evaluation. 98 usability problems were in the first version of *Bia*, of which six were considered bugs. The most addressed heuristics were the mobile heuristics (MH): **MH 2** - Use a theme and consistent terms, as well as conventions and standards familiar to the user (18 problems), **MH 6** - Design a visually pleasing interface (8 problems), and **MH 11** - Facilitate easier input (8 problems). There were five main problems: the lack of prioritization of the main functionalities, overly complex information input, disengaging content, and poor findability of emergency information. We presented initial redesign proposals of some screens to better demonstrate the possible solutions to the project team, and later on, those screens were used as reference during the design of the medium-fidelity prototype (e.g., Figure 3-B). Further details about this evaluation is described in Pinheiro et al. (2020).

6.2 User research

The survey collected a total of 313 participants. Most of our respondents were between 18 and 29 years old (92.97%) and were undergraduate students (63.9%). The participants (175 male, 125 female, and 13 non-declared/non-binary) were mainly from Ceará (92%), the others were from other states of the South, Southeast, and Center-west regions of Brazil. A more detailed characterization of the respondents is displayed in Table 1.

Table 1. Initial survey - Sample characterization.

Gender	Number and % of respondents
Male	175 (55.91%)
Female	125 (39.94%)
Non-binary	12 (3.83%)
Non-declared	1 (0.32%)
Age range	
18 - 24	225 (71.88%)
25 - 29	66 (21.09%)
30 - 34	17 (5.43%)
35 - 39	3 (0.96%)
> 40	2 (0.64%)
Education level	
Middle School or below	4 (1.28%)
High School	28 (8.95%)
Undergraduate student	200 (63.9%)
Undergraduate Degree	51 (16.29%)
Master's/Doctoral student	14 (4.47%)
Master's/Doctoral Degree	16 (5.11%)
Family monthly salary range	
R$0 - 1100	27 (8.63%)
R$1100 - 1819	60 (19.17%)
R$1819 - 7278	149 (47.6%)
R$7278 - 11001	44 (14.06%)
> R$11001	33 (10.54%)

Concerning drug use frequency, 45% of the participants claimed to consume every day, 23.64% sometimes a week,

[7] Available in: `https://www.ueq-online.org`

Figure 3. (A) Consumption formulary of Bia 1.0, (B) low, (C) medium, and (D) high-fidelity screens of the consumption formulary.

20.77% sometimes a month, and 10.54% sometimes per year. Within this group, a total of 277 (88.5%) participants stated that they searched about psychoactive drugs at least once. Considering the information search frequency, 38.02% of the participants claimed they search about drug-related information regularly, while 17.57% only browse it before consuming a new substance. The top three topics of interest were **1)**Having a better understanding of the effects of the drugs they use; **2)**How to have a safer drug use; **3)**How to verify the substance's quality. Table 2 shows the other frequency percentages.

Table 2. Initial survey - Sample's (n=277) drug-related information research frequencies.

Search frequency	Number and % of respondents
Never searched about it	36 (12.46%)
Searched once	11 (3.51%)
Search sometimes	92 (29.39%)
Only search when they want to try a new drug	55 (17.57%)
Regularly searches about drug-related information	119 (38.02%)

Within this group, most participants (79.78%) claimed that they got informed about drug-related information by chatting with friends and colleagues. Other popular sources were YouTube videos (53.79%), social media (52.71%), sites focused on drugs (51.99%), and scientific books and articles (43.68%). Table 3 shows the ranking of all sources that the participants mentioned.

We also asked participants to classify their knowledge about recreational drugs and harm reduction practices from "1-Zero knowledge" to "5-Very knowledgeable". The participants' mean score was 3.65, while the mode and median scores were 4.

Considering their consumption monitoring frequency, 45.69% of the users claimed that they always mind their drug use, while 29.71% claimed that they monitor sometimes, 12.14% hardly ever, and 12.46% of them never monitor it. Within the group of users that monitor their consumption

Table 3. Initial survey - Sample's (n=277) drug-related information sources.

Information source	Number and % of respondents
Chat with friends and colleagues	221 (79.78%)
Youtube videos	149 (53.79%)
Social media	146 (52.71%)
Sites focused on drug-related information	144 (51.99%)
Scientific books and articles	121 (43.68%)
Health professionals	94 (33.94%)
News sites	93 (33.57%)
Podcasts	43 (15.52%)
Other	7 (2.53%)

(n=274), 83.21% claimed that they only keep track of their usage by memory, while the remaining use additional gadgets such as digital or physical diaries and notebooks (14.96%), digital calendars (8.03%), and other specific mobile applications (6.2%). Only a few respondents talked about their tracking motivations: to correlate drug use to mood and physical conditions, avoid and monitor possible overdoses, and control and reduce drug consumption because of health problems.

We also listed a few features related to *Bia* and asked them to mark their range of relevance using a 5-point Likert scale. The five more relevant features for the public according to their means were: **1)** "Being able to access information related to drug consumption emergencies or bad trips" (Mean=4.81, SD=0.617); **2)** "Being able to access general information about drugs, such as effects and precautions" (Mean=4.60, SD=0.845); **3)** "Being able to receive a notification when the consumption frequency of one drug is too high" (Mean=4.49, SD=0.973); **4)** "Displaying a list of recommended discussion forums and other media (e.g., documentaries, movies, podcasts) related to the topic" (Mean=4.41, SD=0.89); **5)** "Being able to set a password to prevent other people from accessing the content of the application" (Mean=4.40, SD=1.084).

Four profiles were identified within this sample: the first type uses different drugs regularly but keeps a close track of their consumption using notepads/mobile applications and is very keen to search thoroughly about a substance before using it. The second profile consumes different substances but only monitors their consumption by memory and does not browse much about drugs. The third profile uses one or two of the most common substances (alcohol and caffeine) and keeps track of their consumption to prevent any degree of addiction. The fourth profile is a casual user and does not have much interest in this topic whatsoever.

6.3 Conceptualization and design of the medium-fidelity prototype

This phase resulted in 37 new possible features divided into five sections. After conducting a prioritization exercise with the project's developers, designers, and psychology consultants, we decided on a final set of 22 features for the MVP - of which nine of them were entirely new. After itemizing the requirements of each feature, we proceeded to design the user interface (UI) using paper prototyping for initial sketches and the Adobe XD prototyping software to develop the medium-fidelity prototype. There were significant modifications in the overall application, and we describe some of the main changes below.

6.3.1 New information architecture and menu navigation

Due to the addition of functionalities, we reorganized the application sections. The 22 features were divided into seven main sections: **Diary, Drafts, Suggestions, Mixture, SOS, Settings,**, and **About the application** (Figure 4).

The **Diary** section remained as a logbook destined to track substance use as it is the core feature of the project's proposal. Besides displaying a calendar and a form to input notes, this section also kept the Statistics dashboard with quantitative information (graphs, scoreboards) of the registered consumption. This combination is similar to the previous version of the application, but we decided to display the calendar in the initial screen of the section to provide better findability and easier visualization of the core feature of the application.

All incomplete consumption entries that were deliberately saved were assembled in the **Drafts** section. There, users could either complete or delete the entry form - something not available in the first version, and we believe it would facilitate easier user input. These features also seek to accommodate users in diverse contexts, as we expect that they may want to register their experience throughout or after the consumption or may be interrupted during the registration.

The **Suggestions** section replaced the Drogapedia section by providing general harm reduction measures. The HCI team had suggested this modification as we thought that the Drogapedia was not a priority compared to the other features, and the recommendations of harm reduction practices should be highlighted. This decision was later proven insufficient to the users' needs based on the user evaluation.

The **Mixture** section was focused on consulting the interaction security between two different substances. The users could choose two drugs from a preset list and see their interaction outcome's description and potential risks. The participants from the user research survey expressed great interest in this functionality. Thus we decided to bring it for the new MVP to attend users' do-goals.

The **SOS** section gathered the features focused on providing practical information that could be useful in emergencies. It was split into three tabs of information: emergency telephones, bad trip coping and prevention recommendations, and points of care. This information was present in *Bia 1.0* but was decentralized. We suggested gathering them due to their purpose similarity; thus, it would enhance these content findability.

We also suggested adding a dedicated section displaying a brief description **About the application** so future users could become acquainted with the project's goal and team. The section displayed information such as the product's purpose, developers, and additional credits - which were unavailable in the previous version. Additionally, we wanted to express reliability and disclose future communication channels, which can be reassuring for the public.

The users could enable push notifications to remind users when they have a saved entry draft and set a password to access the Diary section in the application **Settings**. The first was thought to engage users to finish registration, while the latter was suggested as many participants from the user survey considered this feature relevant to secure that friends or relatives will not access the registered information.

Another modification was the application's navigation between sections. Previously, the navigation was through sequential menus: the user had to start from the home screen and go forth and back through each section to explore the functionalities. This mobile navigation has a moderate interaction cost, but users can quickly lose track of their positioning in the application (Budiu, 2017). Furthermore, this type of navigation did not highlight the application's main functionality. Thus, we switched the sections menu to a fixed bottom bar to facilitate the user visualization and transition between sections. We also set the Calendar with the users' note entries of the Diary section as the home screen of the new version.

6.3.2 New consumption entry formulary

Bia's main functionality is to register and monitor personal drug consumption to understand the users' relationship with drugs better. However, as we saw in the initial survey results, this type of self-monitoring through digital devices is not very common within the targeted public. Thus, these activities should be perceived as valuable and practical enough to encourage users to start and keep using the app for registration.

The entry form of *Bia 1.0* was divided into four parts: before, during, and after the drug intake, and additional comments. The inputs were mostly comprised of text fields, and there were no visual cues that indicated which were the optional and mandatory inputs. Besides, the users did not have the option to save the entry as a draft if they wanted to finish filling up the formulary at another time. Those aspects were identified as usability problems related to the mobile heuristic **HM11 - Facilitate easier input** and **HM10 - Cater for diverse mobile environments**, and had to be fixed for the

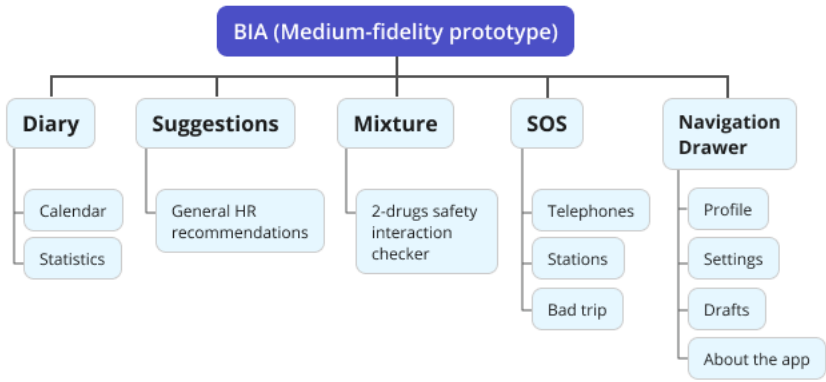

Figure 4. Information architecture of the medium-fidelity prototype

new version.

The new consumption form (Figure 3-D) had additional input fields requested by the Psychology team and was divided into three parts - before, during, and after the drug intake. Some of the input fields were repeated in two or more parts, such as the Companion, Place of use, Emotional and Physical states. Only the mandatory fields were displayed by default, and the elective ones were displayed after tapping the button labeled ”I want to register more details.” We used different select components such as radio buttons, cards, and input chips to facilitate user input and suggested automatizing filling some inputs such as the date and timetable. The new proposal also adopted a 7-point Likert scale for the emotional and physical states entries and has enabled users to save the entry as a draft.

6.3.3 New statistics format

As for the statistics dashboard format, we had to make a design proposal consistent with the new form division and information set. The previous dashboard had three groups of information: a bar chart displaying all registered substances and consumed amount, a donut chart displaying the quality of each substance use, and a list with the substances consumed amount filtered by a specific period. This data set was brought up to better comprehend their relationship with the consumed substances by showing how they felt under distinct variables such as place, substance, and companion. However, the past Statistics section was considered insufficient to infer these nuances promptly. We also noticed that not all requested information in the consumption entry form was displayed and that there were no more filtering or visualization resources.

Therefore, we came up with a simplified proposal that consisted in adding more filtering options (i.e., period and substance) and partitioning the dashboard content into tabs, each highlighting and showing the quantitative of one specific parameter: consumed amount, the experience of use, registered places, registered companions, and finance expenses.

All tabs had a similar interface: the filtering options were in the upper area, then a title of the tab, a counter with the total of days with entries (or the number of different registered options) and sum of entry notes, and a ranking of the registered parameters alongside a card highlighting each item and its number of entries. Some tabs also presented the results of each entry form part (before, during, and after drug intake).

6.4 User testing with the medium-fidelity prototype

The user testing goal was to verify if the pragmatic and hedonic aspects of the redesign proposal were perceived as satisfactory by the targeted public and map possible refinements that would be later implemented in the high-fidelity prototype. We summarize this phase’s sample characterization, data processing, and main findings below.

6.4.1 Sample characterization

We conducted the test with nine users (three male, six female) with an average age of 23. Eight participants were undergraduate students, and one had an undergraduate degree. They were from different fields: Information Technology, Chemical Engineering, Fashion Design, Marketing, Architecture, and UX Design. According to the Brazilian Economic Classification Criteria (APEB, 2019), their economic class varied from C2 to B2, mainly B2 (n=6).

Considering drug consumption behavior, the users claimed that they consume drugs weekly (n=3) or every day (n=6). They consumed at least two out of the eight substances listed in the volunteering application form, with an average of 3.67, maximum and mode values of 5 substances. The most commonly consumed drugs were caffeine, alcohol, cannabis, and nicotine.

The participants showed different answers about searching drug-related information. Three people claimed to search about it regularly, and three searched when they were interested in trying a new substance only. The remaining three either never searched about it or searched sometimes. As for their follow-up practices, most participants kept track of their drug use solely by memory. Only one participant claimed to follow their consumption with a mobile application.

6.4.2 Data processing

We first transcribed the recorded audio and videos of the user tests for the qualitative data analysis. All comments, suggestions, and observations were interpreted and categorized using the Content Analysis technique (Moraes, 1999).

There were nine information categories (e.g., ”Prototype limitations,” ”Suggestions,” and ”Problems with the Information Architecture”) and comprised 23 subcategories that were aligned with the evaluation goals. After the content analysis, we grouped the comments related to the same interaction task and application section for better assessment.

We used six different labels concerning the users' task performance, indicating whether the activity was fully completed or not, if the user made mistakes, had doubts, or failed to complete due to prototype bugs. The test conductor categorized the performances during the regulated interactions and double-checked the categorization afterward by consulting the recorded videos and notes. Then, we generated graphs of each task to overview the tasks' performances.

We organized the SAM scores of all tasks and participants in a spreadsheet and compared their average, minimum, maximum, and median scores to access the users' affective responses to each task. Figure 5 displays the collected user responses of each SAM sub-scale concerning the overall interaction with the medium-fidelity prototype, which we could identify that users were mostly satisfied and stimulated by the application, and also mostly felt in control throughout the interaction. We also placed the NPS scores and the users' preferred features in the same table to visualize more correlations.

Lastly, we gathered all the processed data in a worksheet for qualitative and quantitative analysis. This overview allowed us to observe which tasks the users had more problems with, complemented by the think-aloud protocol and post-interaction interview data.

6.4.3 Key findings

The qualitative and quantitative analysis of the processed data gave us essential insights about which design decisions we should follow and what aspects needed to be adjusted to provide a positive experience for the targeted public. We summarized the main findings of each section below:

Diary. This section had the most incomplete tasks and doubts. When performing the drug experience registration, two-thirds of the users partially completed the task. This task's means and minimum SAM scores were, respectively: 7 and 5 for pleasure (SD=1.225), 6 and 3 for arousal (SD=1.936), and 7 and 4 for dominance (SD=1.856). We observed that the users did not comprehend the form division promptly (i.e., Before, During, and After drug use steps), hence suggesting that the form progress indicator was not evident enough - which we deduced that it affected their understanding of how the form had to be filled out as some users did not complete all required inputs. Three participants suggested shortening the entry form.

Many users also had doubts when consulting specific data in the statistics subsection. The task required applying two filters to visualize specific data, but four users did not complete the task, suggesting that the filtering bar was not evident enough. Some participants commented that they were slightly confused with some scoreboards and the term addressed to the drug entries. Nevertheless, when analyzing the SAM scores, we observed that seven users were satisfied, four felt stimulated with this task, and six felt in control.

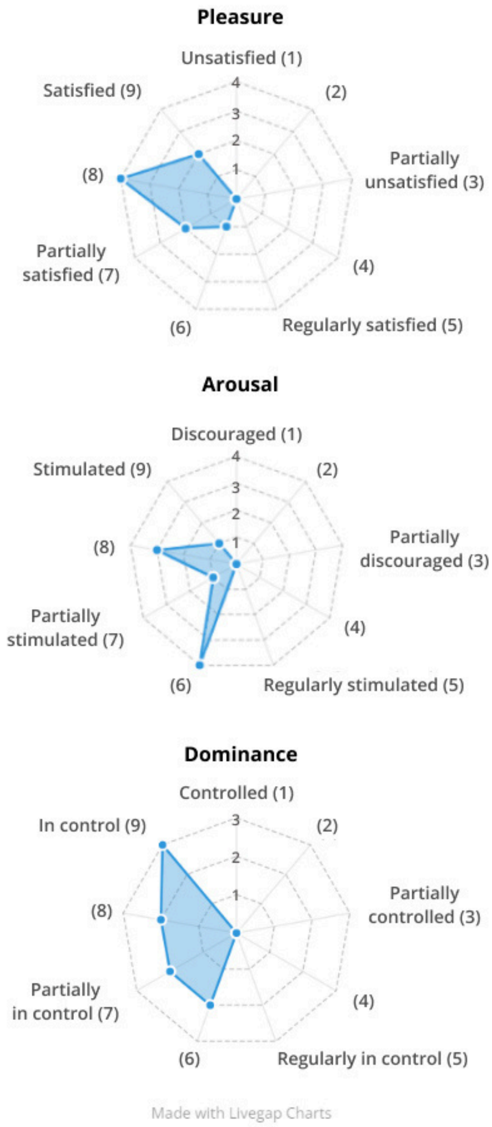

Figure 5. Users' pleasure, arousal, and dominance scores with the medium-fidelity prototype.

Although the task performance indicated that the Diary section had more room for refinement than the others, most users considered it one of the most important application features. Many users commented positively about registering and visualizing the overview of the drugs finance expense and physical/mood experiences.

Settings. The users had to register a password for the Diary section. All participants managed to finish the task, but four people encountered prototype bugs. The SAM means were 9 for pleasure (SD=0.928), 7 for arousal (SD=1.0), and 9 for dominance (SD=1.481). The mode score was 9 for the three aspects. Based on the user performance, SAM responses, and interview comments, most users liked this feature for privacy purposes but pointed out that the visible calendar entry markings were a problem.

Suggestions. The required task was to consult general harm reduction recommendations using the prototype. All users managed to complete the task related to this section, but four users expressed uncertainty. The participants explained that their doubts were related to the section's content because it did not meet their expectations, so they were unsure if they accessed the correct section. The SAM means were 7 for pleasure (SD=2.236), 6 for arousal (SD=2.179), and 8 for dominance (SD=2.872). We observed that many users did not feel fully satisfied or stimulated even when feeling in control in this task. They expected to have more specific information about drugs. Thus, our previous decision of not prioritizing the Drogapedia section for the MVP was proven to be wrong.

Mixture. For this section, we asked the users to consult the interaction quality between two substances. All users completed the task, but three participants first thought this feature was in the Suggestions section. Concerning the SAM responses, the means were 8 for pleasure (SD=1.481), 8 for arousal (SD=2.121), and 8 for dominance (SD=1.59). In general, the comments from the interview were very positive, and five users picked this section as one of the most relevant of the application, and it would be convenient as they consider the available information about drug interactions too decentralized on the web. The users suggested adding one more substance input and anti-depressive and anxiety medication to the substances list. Some users mentioned how they expected that the mixture feedback would be more highlighted.

SOS. We asked the users to find specific information in this section. Eight users performed the task easily, while one person presented doubts. All participants considered that this section was essential and had easy navigation, and also added that they think it could be helpful in emergency events that they already had witnessed before. The SAM scales were all positive: the average scores were 9 for pleasure (SD=0.882), 8 for arousal (SD=1.394), and 9 for dominance (SD=1.13).

Although the design proposal presented some problems (mainly layout and interaction cost), all participants understood and received the application proposal very well. The users made some suggestions that were also taken into consideration. Concerning the Net Promoter Score (Reichheld, 2003), five users claimed that they were highly likely to recommend the *Bia* application (i.e., promoters), three classified that they were passively satisfied, and there was one detractor (i.e., rated between 0-6), resulting in an NPS score of 45. According to the Retently 2021 NPS benchmark for business-to-consumer companies (2021), this score is above the average scores presented in the Internet Software Services (NPS=39) and Healthcare industry (NPS=38). Considering that it was a medium-fidelity prototype, this represented that *Bia 2.0* was going in the right direction but needed some refinements.

6.5 Designing the high-fidelity prototype

After analyzing the user testing results and discussing the findings with the psychology and developments teams, we proceeded to design the last prototype using the Figma prototyping tool. We highlight the main adjustments below.

6.5.1 Adjustments in the information architecture, navigation, and addition of features

First, we adjusted the application's information architecture by reallocating, renaming, and adding some features, resulting in the architecture displayed in Figure 6. We reallocated the Drafts feature from the navigation drawer to the Diary section to solve the findability problem we observed in the user testing.

We also reallocated the access to the **Password setting** to the navigation drawer. In the medium-fidelity prototype, the users had to follow the route *Navigation drawer > Settings > Password settings* to set a password for the Diary section. Some participants in the user testing thought that this feature was a bit hidden, so we shortened the interaction flow. Besides this adjustment, we also added shortcuts in the navigation drawer to provide more flexible and practical user navigation.

As for the new features, we added the **Record download** function by the psychology team's request. This function would download the registered consumption notes of a selected period, and is necessary for their long-term experiment with real users and future psychological counseling contexts, as the psychologists might need to consult the users' self-reported consumption. In our perspective, this functionality will facilitate the consumption follow-up considering that the application will not be linked to an e-mail and the users will only need to download and send a document.

Another addition was the specific **Help** segment for each functionality, enabling users to consult further description and guidance about the application features. All help articles were gathered in the *Navigation drawer > Help Tutorial* section for better access. We proposed to display a quick tutorial when the user accesses the application for the first time. The tutorial presents *Bia*'s main features through dialogs and markings, and users could either dismiss it or play it again by accessing the Help Tutorial section. These adjustments seek to address one of the identified gaps of *Bia*'s preliminary version and to attend to the usability heuristic for mobile applications entitled "**MH4** - Display an overlay pointing out the main features when appropriate or requested" (Joyce and Lilley, 2014). We believe that this new section will support users in familiarizing themselves with the application.

The Suggestion section was replaced by the **Drogapedia** section (Figure 7) after we identified in the UX evaluation that the first did was not sufficient to attend to users' expectations and needs. In the initial screen, we display a list of 10 substances with their respective classifications and personalized icons. We also suggested that every substance article in this section should follow the same content structure for internal consistency, which comprised four topics: drug effects, safe consumption methods, interactions with other substances, and information references. This decision addressed one of the identified problems from the multidisciplinary evaluation: the preliminary version's Drogapedia did not have a standardized content structure. Additionally, we suggested complementing the safe consumption methods with illustrations to make the content more appealing. We also inserted a fixed bar for better navigation through the article information topics. Figure 7 shows a comparison between

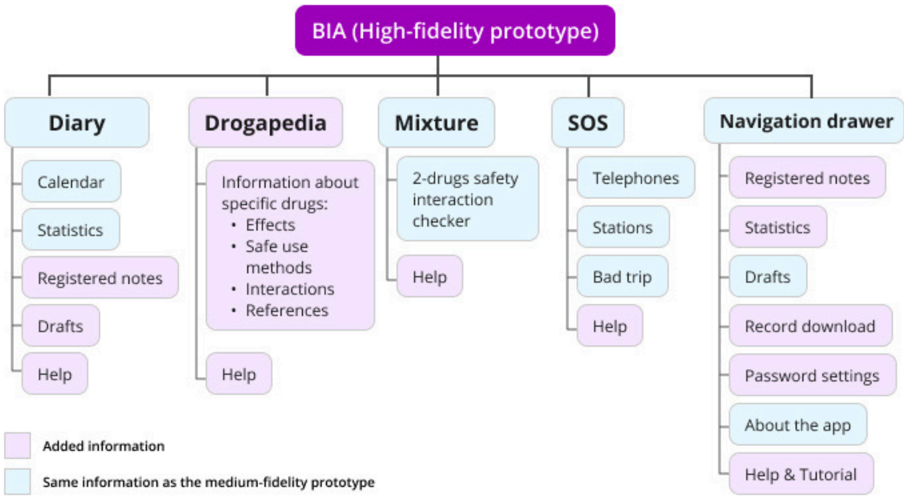

Figure 6. Information architecture of *Bia*'s high-fidelity prototype

Bia 1.0 (A) and 2.0 (B) versions of the Drogapedia screens.

Figure 7. (A) *Bia 1.0* and (B) *Bia 2.0* versions of the Drogapedia inital screen

6.5.2 Diary visualization

We implemented a few adjustments in the Diary section to correct the observed problems in the previous user testing. The changes were mainly in the Calendar visualization, Consumption entry formulary, and Statistics subsection.

Calendar: We changed the layout and interaction by adding one button for the registered and draft entries, and one button to hide/show the calendar entry markings and disable/enable access to all registered data. If the user has set a password, he will be required to insert the PIN to show the registered consumption information. These changes addressed the privacy and information architecture gaps identified in the previous prototype. Figure 12 shows a comparison between *Bia* 1.0 (A) and 2.0 (B) versions of the Calendar visualization.

Consumption entry. As for its entry form (Figure 12-B), we had to refine the layout and navigation for easier user input. First, we redesigned the progress bar to make it more evident and established two ways to navigate between the form steps: swiping left or right or tapping on the progress bar tabs. We also adjusted the select inputs to have less interaction cost to facilitate easier input as some participants found them too complex. As this registration activity is expected to be conducted repeatedly, providing easier input is important to not frustrate the end-users.

Statistics. After analyzing the user testing findings and the considerations from the Psychology team, we upgraded the Statistics subsection as our previous proposal was too simplified and insufficient to make significant conclusions about the users' drug use experience. Thus, we had to redefine how the registered data would be compiled and displayed.

First, we maintained the subsection tab division of the medium-fidelity prototype but changed the navigation bar position and switched the icons for text labels, resulting in the renamed tabs of Consumption, Experience, Places, and Companions. Then, we changed the filtering buttons as we observed that they were not evident enough. The period visualization setting was reallocated to the fixed top bar and set as a global configuration (i.e., it applies to all tabs) and not internal to each tab. The users can configure whether they want to visualize the statistics per week, month, bimester, quarter, semester, or year. As for the parameter setting button, we put it as a tertiary button labeled "Change" next to the selected parameter title. The users may choose to visualize an overview or more detailed information about a specific parameter (i.e., a specific substance, place, or companion) with this feature.

The overview of the Consumption tab has three information blocks: first, it shows the total of consumption entries and consumed substances of the specific period. The second block shows a bar chart with the quantitative of entries per day or month and a ranking of all registered substances according to the number of entries. The third block focuses on the financial expenses through a doughnut chart and a list of expenses per drug. The visualization of a specific parameter is similar, but it displays the expenses per registered unit measure (e.g., per alcohol bottle, shot, glass). Figure 8 displays the comparison between the 1.0 and 2.0 versions of the

Statistics visualization.

Figure 8. (A) *Bia 1.0* and (B) *Bia 2.0* versions of the Statistics visualization

The Experience, Places, and Companions tab follow the same informational structure. These tabs show the correlation between the registered substances, places, and companions with the users' emotional and physical states before, during, and after the drug use. In the overview mode (Figure 9-A), we display four information blocks. The first block shows four cards with the registered option with the most positive and negative emotional/physical states and their respective percentage. The second and third blocks display a line chart with the quantitative number of entries related to each experience state and drug. The last block shows a ranked list of the registered substances and each consumed amount. The visualization of a specific parameter is similar but only shows the users' most common states related to that parameter and two bar charts for the quantitative number of entries of each experience state (Figure 9-B).

The purpose of clustering this information is to enable users to visualize important patterns about their consumption. For example, seeing the highlights of the experience with substances may present that they should be careful about a specific drug if they usually score their experience as unfavorable. The same goes for apparent unfavorable places and companions. The rankings of most consumed substances and financial expenses may help users visualize how much they have been expending and consuming for their standards and relate it with their mood swings and life moments.

6.5.3 Refinement of the visual identity

After making the layout and interaction adjustments, we established the color palette, typography, iconography, and illustration of *Bia 2.0*. In the multidisciplinary evaluation, we have considered that the color palette of *Bia*'s preliminary version did not match the application's proposal, so we suggested a new one. We aligned *Bia*'s visual identity concept with the Psychology team, and we agreed that it should evoke a sense of friendliness, reliability, calm, and youth. After some tests, we came with the palette displayed in Figure 10, where the primary colors are a shade of blue, purple, and a

Figure 9. *Bia 2.0* (A) overview and (B) specific parameter visualization of the Statistics > Experience tab.

gradient with those two colors, and the secondary colors are a shade of orange and off-white.

Figure 10. *Bia*'s primary and secondary colors. From left to right: purple (A762FF), blue (80E0FF), orange (80E0FF), gradient, and off-white (FDFDFD)

We chose purple as it is commonly associated with singularity, authenticity, and youth (Kaya and Epps, 2004; Clarke and Costall, 2008; Heller, 2013). This color also conveys calm and relaxation for some people and in certain shades - which is why some meditation and mental health applications also use purple as their primary color. As for the color blue, we chose it because it is the favorite color of many people, and it is commonly linked with harmony, comfort, trust, and calmness (Kaya and Epps, 2004; Clarke and Costall, 2008; Heller, 2013) - therefore, it is also prevalent among health-related products. We chose to apply a gradient with both colors to "combine" the color concepts and avert from the monochromatic monotony. The blue-purple spectrum also enhances positive emotional responses (Kaya and Epps, 2004).

As for semantic colors, we established different colors for the physical and emotional states and statistics data visualization. The physical and emotional states are displayed as a 7-point pictorial scale to signalize whether users are feeling *"1-Very bad"* or *"7-Very good"*. Thus, we suggested that both states have a sequential color scale based on a single hue for better memorization. According to (Wilke, 2019, p.29), such a scale "clearly indicate which values are larger or smaller than which other ones, and how distant two specific values are from each other." As for the base hue, we chose two complementary colors - purple to represent the emotional state and yellow to represent the physical state - as in the application context, the combination of the two scales represents the user's consumption experience. Figure 11 shows the resulted experience scales of *Bia 2.0*.

Figure 11. Physical (yellow) and Emotional (purple) scales of *Bia 2.0*

The Statistics data visualization has three color patterns: one for the Overview visualization, one for the specific parameter visualization of the Consumption tab, and one for the specific parameter visualization of the Experience, Place, and Companion tabs. In the overview visualization, we employed a qualitative color scale for better graph readability, as this type of scale has a set of very distinctive yet harmonizing colors and is frequently used to "distinguish discrete items or groups that do not have an intrinsic order" (Wilke, 2019, p.27). For the specific parameter visualization of the Consumption tab, we used a sequential scale palette based on a single hue as we focused on quantitative data values related to the same substance. Lastly, we used the experience scales' base colors for the specific parameters of the other tabs as the only displayed graphs are about the emotional and physical states.

The chosen typography was the Work Sans, a sans-serif font under the Open Font License that has a broad set of weights, good readability, and expresses friendliness and comfort. The icons were from open source libraries such as Google Icons and free-to-use libraries available in platforms such as Flaticon and Freepik. The illustrations are from the Freepik Storyset library, but we hope to develop an original illustration set for the application in the future.

6.6 Preliminary UX evaluation of the high-fidelity prototype

6.6.1 Sample characterization

Our main targets were young adults that consume psychoactive drugs regularly. We collected 55 answers, but six were discarded because they either did not consume drugs or presented inconsistent answers for the UEQ - resulting in a sample of 49 participants (20 male, 26 female, and three others).

Most of our participants were undergraduate students (55.1%) and from the state of Ceara (83.67%). Considering drug consumption behavior, the majority of the respondents consume drugs every day (38.78%) or weekly (28.57%). The most commonly consumed drugs were caffeine, alcohol, and cannabis. About their search frequency about drug-related information, most claimed that they search about it sometimes (40.82%), 20.41% only when interested in trying a new substance, and 18.37% sometimes. As for their follow-up practices, 89.8% keep track of their consumption somehow, but primarily by memory only (86.36%). Only 11.36% of the users use other gadgets to monitor their usage within this group.

6.6.2 User Experience assessment

The high-fidelity design of *Bia* got a pragmatic quality score of 2.13 and a hedonic quality score of 1.93. Hence, the overall attractiveness of *Bia* was also positive, with a score of 2.42.

The collected mean score of each scale was automatically attributed and compared to the existing benchmark data set by the UEQ analysis tool, which comes from a data collection of 21175 people and 468 studies related to different products. According to the comparison, *Bia*'s presented excellent scores in all scales because all scales presented values in the range of the 10% best results of the existing data set (Table 4). The scales with the highest means were attractiveness (mean=2.422, SD=0.696) and perspicuity (mean=2.265, SD=0.859), and the lowest scores were dependability (mean=1.893, SD=0.760) and novelty (mean=1.898, SD=0.989).

Table 4. UEQ means and alpha values of *Bia 2.0*.

Scale	Mean	Alpha
Attractiveness	2.422	0.88
Perspicuity	2.265	0.86
Efficiency	2.224	0.81
Dependability	1.893	0.62
Stimulation	1.959	0.84
Novelty	1.898	0.70

All items from the UEQ presented more positive than negative answers. The opinions with the highest means and lowest standard deviation values (Figure 13) were that *Bia 2.0* is "enjoyable", "good", "understandable", "interesting", "organized", "attractive", and "friendly". However, we observed that the new version can still improve in terms of stimulation, dependability, and novelty as the items with lower means were related to *Bia 2.0* being "motivating," "exciting," "predictable," and "leading edge."

On a closer look, the scales presented standard deviation (SD) values in a range of 0.696 to 0.989. The scales with higher dispersion were the stimulation (SD=0.889) and novelty (SD=0.989) scales, while the scales with lower dispersion were attractiveness (SD=0.696) and dependability (SD=0.760). Analyzing the standard deviation values of all 26 items of the questionnaire, we identified that the participants presented higher dispersion of opinions in terms of the application being "usual" or "leading edge" (mean=1.286, SD=1.633), but had a more focused opinion about *Bia* being "annoying" or "enjoyable" (mean=2.592, SD=0.705). Nevertheless, the distribution of answers per item showed that most of the user opinions regarding all items were on the positive side, with fewer samples on the side of negative and neutral responses. Figure 13 shows the means, standard deviations, and variances of all questionnaire items.

As for the confidence intervals of each scale, the analysis tool generates a figure presenting the scale means and error bars that represent the 5% confidence intervals for those values. Figure 14 shows our collected UEQ scale charts and respective error bars.

Concerning the data reliability, we accessed the internal consistency of the UEQ scales through the Cronbach's Alpha coefficients that were automatically calculated by the analysis tool. The alpha values (Table 4) indicated that all scales were sufficiently consistent (i.e., with values above 0.7) except for the dependability scale, which got a slightly lower alpha value of 0.62. This probably happened due to misinterpretation of some items because of the application or use

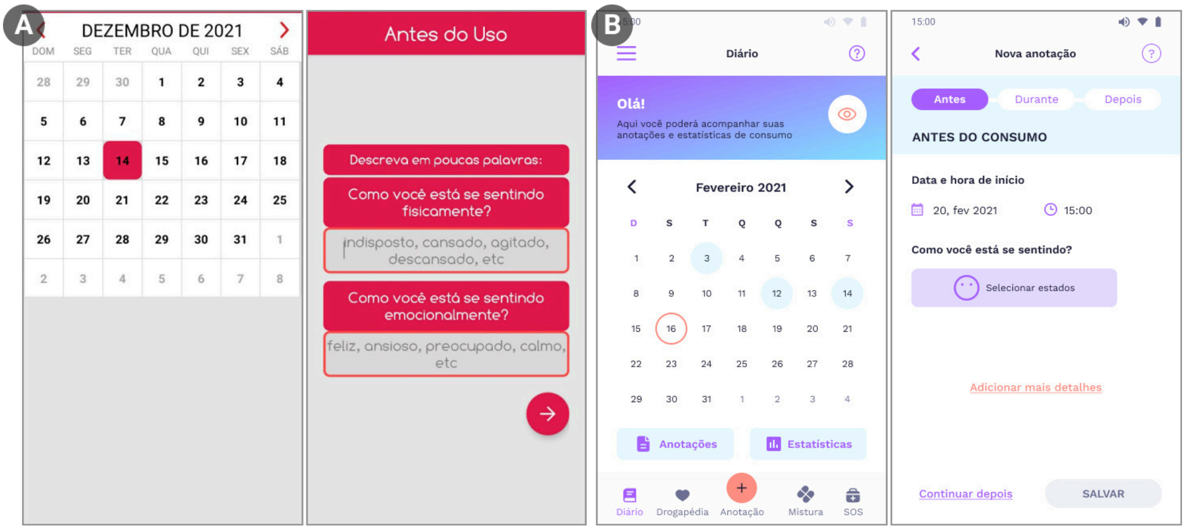

Figure 12. (A) *Bia 1.0* and (B) *Bia 2.0* versions of the calendar and consumption entry

Item	Left	Right	Mean	Variance	Std. Dev.	Scale
1	annoying	enjoyable	2,592	0,497	0,705	Attractiveness
2	not understandable	understandable	2,51	0,672	0,82	Perspicuity
3	creative	dull	2,102	1,927	1,388	Novelty
4	easy to learn	difficult to learn	2,204	1,249	1,118	Perspicuity
5	valuable	inferior	2,204	1,166	1,08	Stimulation
6	boring	exciting	1,469	1,421	1,192	Stimulation
7	not interesting	interesting	2,388	0,701	0,837	Stimulation
8	unpredictable	predictable	1,204	1,332	1,154	Dependability
9	fast	slow	2,082	1,077	1,038	Efficiency
10	inventive	conventional	2,204	1,541	1,241	Novelty
11	obstructive	supportive	1,918	1,16	1,077	Dependability
12	good	bad	2,592	0,705	0,84	Attractiveness
13	complicated	easy	2,347	0,731	0,855	Perspicuity
14	unlikable	pleasing	2,224	1,053	1,026	Attractiveness
15	usual	leading edge	1,286	2,667	1,633	Novelty
16	unpleasant	pleasant	2,122	0,943	0,971	Attractiveness
17	secure	not secure	2,184	1,153	1,074	Dependability
18	motivating	demotivating	1,776	1,386	1,177	Stimulation
19	meets expectations	does not meet expectations	2,265	1,282	1,132	Dependability
20	inefficient	efficient	2,143	1,292	1,137	Efficiency
21	clear	confusing	2	1,708	1,307	Perspicuity
22	impractical	practical	2,143	1,042	1,021	Efficiency
23	organized	cluttered	2,531	0,713	0,844	Efficiency
24	attractive	unattractive	2,51	0,797	0,893	Attractiveness
25	friendly	unfriendly	2,49	0,797	0,893	Attractiveness
26	conservative	innovative	2	1,5	1,225	Novelty

Figure 13. Means, standard deviations, and variances of all UEQ items.

contexts and due the linguistic variations from the Brazilian Portuguese as we employed the European Portuguese of the questionnaire. For example, a few of our participants reached out to ask about the item ”obstructive/supportive” from the

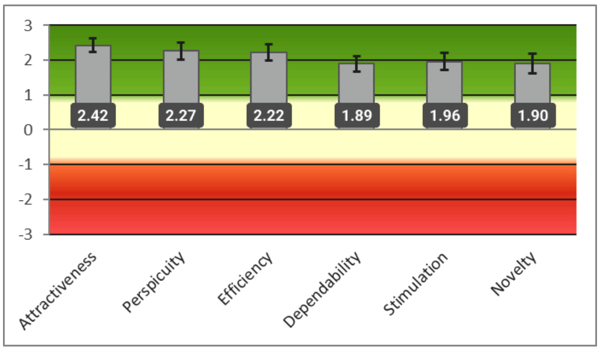

Figure 14. Bar charts with confidence intervals for the scale means.

dependability score as those terms are not very usual in this context."

6.7 Creating a Design System for the project

Lastly, we created a Design System document of *Bia* in Figma to better assist the development team and facilitate the implementation of future design updates. We compiled the visual identity components (e.g., color pallets, typography, icons, illustrations, and system components), the dataflow diagrams and screenflow of all features, informational architecture diagrams, and other textual descriptions and visual specifications. We also added external links for additional requirements and collected data documentation. This type of document is essential as it establishes a type of "handbook" of how the final product should be while preventing programmers from making their own requirements and preventing the costs of personnel turnover (Parnas and Clements, 1986).

7 Discussion

This section discusses the synthesis of the redesign process and evaluations. We highlight the main challenges, recommendations, and limitations identified throughout the development of this study.

7.1 Overview of *Bia*'s redesign process

After a multidisciplinary evaluation of *Bia*'s interface, content, and functionalities, it was decided that the application should be redesigned before disclosing it to real users. From the HCI team perspective, several changes should be made concerning the layout, information architecture, and visual identity of the application (Pinheiro et al., 2020). So for the redesign, we adopted the UCD model, and before proceeding to make design changes, we took a step back and started from the user research step, followed by the conceptualization step.

The user research findings helped redefine the application's scope, as we were able to confirm some of the users' topics of interest - which were very aligned with the original scope of *Bia* - and discover additional requirements. One example of the latter was enabling a password to prevent the visualization of the registered consumption entries by a third party. We presented a list of features then asked the participants to attribute a score from 1 to 5 concerning their relevance, and this functionality got the fifth highest mean with a score of 4.40 and a standard deviation value of 1.084. This result is aligned with Monkman et al. (2015) e-Health usability heuristic labeled *"Protect Users' Privacy"*. In the context of *Bia*, we infer that it is indeed relevant for the users as drug usage is stigmatized in society (Fraser et al., 2020) as they will be inserting personal information about their consumption.

After debating about the new scope of the application and defining the set of features for an MVP, we proceeded to develop and evaluate the medium-fidelity prototype. We were able to collect detailed design and experience feedback from the users, and identify points of refinement in our initial redesign proposal - something feasible with a medium-fidelity prototype (Engelberg and Seffah, 2002). The user testing allowed us to access users' emotional responses towards the application's main activities and identify aspects that had to be refined. We also noticed that the users valued the hedonic aspect more than the pragmatic one, but it could have been since the prototype was still in medium-fidelity. Nevertheless, this pattern was prominent when they interacted with the Diary and Suggestion sections. In the first section, although some users either could not accomplish the task entirely or presented some doubts, they were still satisfied with the features and perceived as very interesting and valuable. As for the Suggestion section, although they quickly finished the task, they were unsatisfied because it did not meet their expectations.

The overview of the medium-fidelity evaluation responses was considered positive but pointed out that our proposal had room for improvement in both hedonic and pragmatic qualities. Thus, we proceeded to adjust many design elements during the high-fidelity prototype development. Due to the study delay, we opted to employ a user survey presenting the application with the UEQ (Laugwitz et al., 2008). Albeit the limitations, according to the collected responses of the questionnaire, the final redesign proposal presented a positive UX in terms of pragmatic and hedonic aspects and product attractiveness. We believe that this was better achieved because of the UCD approach and the involvement of not only end-users, but also designers, developers, and psychologists during the process. UCD techniques have been

7.2 Employing a UCD approach in mHealth development.

UCD techniques are known to help deliver applications with better usability and user experience (Humayoun et al., 2011), which in the mHealth context, can enhance the probability of the intervention's success. The World Health Organization also recommends that user evaluation should be integrated into the development lifecycle of health-related technologies to more effective results (WHO, 2011). It is not uncommon to sometimes make assumptions that are later proven to be insufficient or inadequate after users' input. It also happened to us when we decided to replace the Drogapedia section for the Suggestion one. If it is not possible to apply through the development process, it is suggested to conduct a user evaluation with at least five people (Nielsen, 2000) before a new release or shortly after it to gather users' feedback. Testing the system quality before conducting a clinical trial may even prevent it from being interrupted. One example is a clinical trial of an app for self-management of diabetes and hypertension was paused as the researchers identified that the application presented several UX issues, which resulted in users not using the system appropriately (Thies et al., 2017).

There have been some initiatives trying to bring more HCI techniques such as UCD since the early stages of the development cycle may address the gap on user retention and discuss the challenges within the participation of HCI in e-Health and mHealth studies. The series of challenges even resulted in a proposal of a new Special Interest Group (SIG) for HCI and Health in the Association for Computing Machinery (ACM) (Singh et al., 2017). Unfortunately, integrating HCI expertise, UCD techniques, or conducting usability tests throughout the development process is not the norm. In a systematic review conducted by Chandran et al. (2020), of the 389 retrieved studies, only 20 employed the UCD model. Concerning mHealth for behavior change, in a study by McKay et al. (2018), only 10 out of the 38 analyzed studies evaluated the applications' usability.

Thus, our study seek to reinforce the importance of employing UCD techniques and working with a multidisciplinary team since early stages of mHealth development to verify and maintain a positive experience for users. Besides the participation of end-users, the participation of different stakeholders such as developers, and the medical/psychological team, are also valuable to ensure the project's feasibility and effective scientific-based interventions. In *Bia*'s case, for example, the design decisions were strongly oriented by the psychology team to check if they were appropriate for the users and aligned with the project goals. With their orientation, it was possible to refine some design elements and avoid possible negative reactions: one example was the case of the experiences scales. At first, the HCI team chose some icons to represent the scale extremes that were considered inappropriate by the Psychology team because end-users may consider it hard to relate. We also tried to validate all interactions and functionalities with the Development team to check if they were technically possible within the timetable and their knowledge. We prioritized adjustments that would be technically less complex and of great value to the users.

7.3 Design challenges and recommendations

In this section we pinpoint some of our challenges and respective recommendations based on our redesign context and established interface recommendations (e.g. Nielsen, 1994; Monkman et al., 2015; Inostroza et al., 2016; Sharp et al., 2019).

C1: Designing for harm reduction practices. As a supporting tool, it is expected that users might interact with the application under the effects of drugs or might be in negative emotional and physical states. Hence, it is vital to provide accurate information about the substances' recommendations and risks in an objective and comprehensive way. Thus, it is recommended to work on layered content and, if appropriate, with the addition of visual components (e.g., illustrations) that complement the textual information (Monkman et al., 2015). In addition, it is essential to establish a logical and simple informational structure and screen sequence to enable users to navigate through the application easily. The way that the information is displayed visually is also relevant, and it is further discussed in the next topic.

Regarding the *Bia*'s proposal of promoting self-awareness about the user's relationship with drugs, it is advised to avert value judgment undertones. The HR model seeks to respect the individual's choice and condition regarding drug use and focuses on mitigating the potential harmful consequences of it (Machado and Boarini, 2013). Thus, it is adequate to avoid any textual or visual components that might label any aspect of the user's consumption behavior, such as usage frequency and consumed amount. On the other hand, the presentation of drug interaction risks has to be highlighted and straightforward for the liabilities to be communicated as clearly as possible.

Another aspect that the psychology team reinforced is avoiding triggers that may encourage drug consumption or denote approval upon registering the consumption. Some aspects that designers should beware of are push notifications or textual dialogues. Related to this, it is also crucial to protect users' privacy. Studies such as of Zhang et al. (2014) indicate that privacy issues can affect user adoption of mHealth applications. Similarly, Guo et al. (2016) observed that this aspect influences users' trust significantly.

Recommendation 1.1: Communicate the information clearly and in a friendly way through layered content. Avoid overly technical and formal speech. If suitable, complement the content with self-explainable visual elements such as illustrations and icons that are visually consistent with the design theme.

Recommendation 1.2: Highlight safety-related information about drugs and their interactions visually by employing visual elements (e.g., larger buttons, images, and higher contrasting colors) along textual content. Place the information in prominent positions on the screen and in convenient contexts, such as when users are registering or consulting about a substance.

Recommendation 1.3: Avoid textual or visual components that might distress or embarrass the users, or denote value judgment towards what is being consulted or registered in the application concerning their personal consumption.

Recommendation 1.4: Offer password or identity verification mechanisms to secure the users' registered drug usage data.

C2: Creating the design theme for a health-related application. It is proven that interface aesthetics has a relevant role in the users' experience with a system, as aesthetically appealing interfaces are perceived as more usable by the users (Kurosu and Kashimura, 1995; Tractinsky et al., 2000). Besides influencing the hedonic aspects of the experience, it is also vital for the pragmatic factors. Inserting appropriate visual affordances, for example, are essential to guide users on how to use the system (Norman, 1999).

In the context of mHealth, it is not uncommon to see applications that are lacking in terms of aesthetics (IMS, 2015). Thus, we highlight the importance of a pleasant design theme that matches the product's purposes, contexts of use, and the targeted public's mental model. By design theme, we refer to the interface's chromatic composition (i.e., color palette), iconography, typography, and additional visual elements such as photographs and illustrations.

In *Bia*'s case, for example, we wanted that the end-users perceived the application as friendly, reliable, and comfortable to use. Aiming to express those concepts through the visual design, we paid attention to the interface's color palettes and illustration, iconography, and typography styles. We tried to pick colors that better matched our concept based on their most common semantic nuances and emotional responses while also considering their combination contrast. As for the graphical elements, we opted for a more minimalist and "rounded" style.

Recommendation 2.1: Combine icons and labels when displaying substances and when suitable. Both elements should be aligned with the targeted users' mental model and language. This combination might help users recognize the drugs as there are multiple terms addressing the same substance.

Recommendation 2.2: Mind the semantic connotations of the employed colors for specific contexts of drug use. For example, when reporting the consequences of drug interactions, avoid using the color green even when reporting low-risk interactions as green is commonly used for affirmative and positive feedback.

Recommendation 2.3: Mind the possible emotional evocations of the employed colors. Avoid color tones that are commonly related to negative emotions or that may evoke high level of stimulus as there is a possibility that they might consult the application when under the effects of substances or suffering from bad trips.

Recommendation 2.4: Employ iconography, typography, and images that are visually consistent with the design theme.

C3: Designing for users' needs and project feasibility. One of the challenges we faced was mediating the targeted public and the psychologists' interests with our limited human and financial resources. The limitations led us to make some design decisions that may not attend to users' needs entirely or were the ideal solution technically-wise, but that were crucial for the feasibility of the project implementation. We point out two examples of how we tried to balance the primary stakeholders' requirements below.

Regarding the Mixture section of *Bia* for example, some users expressed that it would be interesting if they could check the interaction between three substances instead of two. Nevertheless, the psychology team advised that it would be better not to enable it as this type of interaction is highly dangerous and harmful for users. Another example was the establishment of mandatory consumption entry inputs. Some users in both medium and high-fidelity prototype evaluations expressed that they considered the consumption registration form quite long and suggested taking out one or two of the steps (before or after the consumption). However, for the time being, removing the input requirement may affect the application proposal and upcoming experiment negatively as it would directly affect the statistics overview.

In short, there are several design possibilities when developing a system, but we, as designers, have to carefully analyze the better yet feasible options within the specific context of each project. We recommend constant communication with the other teams involved and also the use of exercises such as the threefold analysis suggested by Caroli (2018).

Recommendation 3.1: Foster multidisciplinary cooperation between the medical/psychology team and development teams. This can be promoted through periodical meetings and by providing additional explanation and documentation to better explain technical terms from different domains.

Recommendation 3.2: Always try to find a middle-ground between what is relevant for the project proposal, for the end users, and what is attainable to implement within the technical, time, and human resource limitations of the project.

Recommendation 3.3: Apply prioritization exercises involving different stakeholders to mediate user and project requirements.

C4: Facilitating remote workshops and evaluations. Due to the sensitivities around the expected usage context of *Bia* and the social distancing measures, we did not conduct field evaluations and employed structured online evaluations. In situations like these, remote work is a feasible solution that requires precautions and preparations.

Remote evaluation settings have the advantage of being able to provide a familiar environment for the participants if home-based testing is allowed, but present reduced experimental control as users may be more distracted during the activities (Albert et al., 2009). Thus, it is important to adapt the activities structure and online forms to mitigate participant weariness and distraction.

Some of the recommendations for remote work facilitation are providing instructions and planning technology challenges before the appointed meetings and experiments. Preparing a simple document, meeting, or video summarizing how the activity will be conducted and which tools are going to be used might be helpful to prevent drawbacks during synchronous remote activities. It is also recommended to choose free-to-use platforms and familiar tools to accommodate the participants better as new users may not be willing to spend too much time and effort learning to use new tools (Fessenden, 2020).

Recommendation 4.1: Provide explanatory documentation about the procedures to the participants prior to the remote workshops and testings. Information such as the expected duration of the online meeting, which platforms are going to be used and how to use it, the purpose of the meeting, the activities, ethical observations, and additional preparations should be summarized.

Recommendation 4.2: Prioritize online platforms that are free to use and which manipulation is familiar and simple to the participants.

Recommendation 4.3: Avoid projecting meetings with extensive duration. If unavoidable, split the activity into meetings on different days or day shifts.

7.4 Limitations

There are some limitations to this work worth discussing. First, we could not conduct the UX evaluations in real-world contexts due the social distancing measures and the context sensitivity. One of the expected user contexts with *Bia*, for example, is the registration and consultation of information after, before, or during drug consumption. According to Hassenzahl and Tractinsky (2006), field evaluations provide richer data as UX is highly dependent to the user's internal state in the current context.

Due the delays in the research schedule, we only employed an online user survey to evaluate the high-fidelity prototype to consolidate the results of the redesign. Although we presented and described the overall functionalities, the users were not able to explore and observe the application as integrally as in the medium-fidelity prototype evaluation. Thus, some details were overlooked by the participants and we could not map potential interaction problems properly.

When presenting the results of the UX evaluation of the high-fidelity prototype, we highlighted that the Dependability scale presented a slightly lower alpha value of 0.66, which we attribute to participants misinterpretation of some items due the linguistic variations of Brazilian and European Portuguese.

Additionally, our research participants were primarily undergraduate students with a similar profile and from Ceara as we had difficulty reaching different types of people. Although we identified four simplified profiles in the user research step, we had difficulties accessing specific profiles, so the UX evaluations sample embraced users with different usage and monitoring patterns. Thus, our findings and UX evaluation results may not attend to all types of drug users and suffer from a limitation of representativeness.

8 Conclusion and future work

This study focused on the redesign process of *Bia*, a mHealth application directed to promote harm reduction practices (Lima, 2018). We employed UCD techniques to develop a product that will better attend to the users' needs and the project proposal within the time and resources available. The process included seven phases and counted with a user research survey and user evaluations utilizing standardized questionnaires and scales, semi-structured interviews, and regulated interaction - a usual combination used to validate product design and interaction (Vermeeren et al., 2010; Pettersson et al., 2018).

The results of the medium-fidelity evaluation indicated that users valued the hedonic aspects more than the pragmatic aspects of the application. We restructured the application's information architecture for the final design and refined the UI, which resulted in a product that presented positive UX according to the UEQ scores. The implementation of the new version of *Bia 2.0* is still underway. However, these early results demonstrate the importance of the inclusion of end-users, the cooperation of a multidisciplinary team (HCI, psychology, and development teams), and the employment of UCD techniques in creating an appealing mHealth application. We discussed our limitations and pointed out some of the challenges and recommendations of the process that may assist designers and project teams when projecting mHealth applications for harm reduction practices. Another aim of our study is to endorse multidisciplinary work involving HCI, medical, and IT teams in mHealth development and to mind user experience factors since early development stages.

There is more work to do in this study before the official release of *Bia 2.0* in digital stores. A new study employing regulated interaction with real users would be helpful to identify possible improvement points, as well as further analysis of other user profiles. A long-term efficacy assessment with *Bia 2.0* is also needed to evaluate better the application's potential to cater to sustained use and, consequently, promote harm reduction practices in substance use. These evaluations are needed before releasing the application to the general public. The expectation is to continuously investigate the application's performance as a health promotion tool, so future periodical updates are planned.

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