Development of a Computational Platform to Support the Screening, Surveillance, Prevention and Detection of Suicidal Behaviours

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Abstract. The use of new technologies in the prevention and detection of suicidal behaviours have a strong potential to reach and offer immediate support to individuals at risk, their caregivers and in the long run to health care policymakers. In this paper, we describe the development of a computational platform to support suicide prevention activities through two main components. The first one is a Clinical Decision Support System developed to help specialists with the screening, treatment management, and the collection and analysis of suicide-related data for surveillance purposes. The second component of the platform is HelPath, a mobile-based application, addressed to individuals identified with suicidal behaviour (ideation, planning or attempt). HelPath offers support for the remote and continuous collection of data for the assessment of risk factors and offers suggestions and activities based on Cognitive Behaviour Therapy that can prevent to commit suicide. The main functionalities of each component are described emphasising how each of these functionalities impacts in the different key actions required to get an integral strategy for suicide prevention.

Keywords: Suicide prevention · Suicidal behaviours · Clinical decision support system · Embodied Conversational Agents

1 Introduction

According to some estimations of the World Health Organisation (WHO), over 800,000 people die every year around the world due to suicide [44]. The same

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WHO's report highlights that suicide is the second leading cause of death in the 15–29 years old population; it represents the 1.4% of all deaths worldwide, and it was the 17th leading cause of death during 2015. Moreover, there is also evidence that for each individual who commits suicide, there could be 20 others attempting it [35]. These facts reveal how important is to consider the prevention of suicide as a higher priority on the global public health agenda. Nevertheless, an effective prevention of suicide is a not easy task considering that this phenomenon results from a complex interaction of biological, genetic, psychological, sociological, cultural and environmental factors [41]. Although complex, suicide is preventable but it should include an integral strategy involving not only the health sector but also others such as education, employment, social welfare, and the judiciary, to name a few. Important resources are necessary to achieve both short-to-medium and long-term objectives, there should be an effective planning, and the applied strategy should be regularly evaluated to assess its results and identify improvements for the future [42].

In order to facilitate the implementation of different preventive strategies and the involvement of various sectors, there is necessary that national governments adopt a clear commitment to deal with this phenomenon. Currently, some countries have already implemented national prevention strategies such as surveillance, means restriction, media guidelines, stigma reduction and raising of public awareness, crisis intervention services, as well as training for health workers, educators, police and other gatekeepers [42]. Each strategy should be implemented through specific actions allowing the assessment of their effectiveness. In a recent systematic review, seven interventions were assessed to get an updated evidence for the effectiveness of suicide prevention: *(i)* public and *(ii)* physician education; *(iii)* media strategies; *(iv)* screening; *(v)* restricting access to suicide means; *(vi)* treatments; and *(vii)* internet or hot-line support [46]. The obtained results indicate that no single strategy clearly stands above the others, and the efficacy of some of them depends on the groups of population addressed.

The development of ICT-based applications can facilitate the implementation and follow-up of different strategies and interventions at different stages. The potential beneficiaries of these applications are not only suicidal people and their caregivers, but also other key actors such as their relatives, teachers and bereaved survivors [21]. Internet and mobile-based applications can increase the availability, accessibility, and acceptability of different suicidal prevention actions, ranging from the screening of people in risk, the support of psychotherapeutic treatment, the collection and analysis of data for surveillance purposes, to the provision of guided or unguided "self-help" interventions.

Much of these technology-based interventions are relatively new and there is not yet strong evidence about their effectiveness on suicide prevention, but they have the potential to reach and help a larger population of vulnerable people. Moreover, stakeholders of different countries including policy and public management professionals, specialists of the mental health area, and professionals related to the social area and non-governmental organisations, recognised the usefulness and advantages of new technologies as resources that should be incorporated into suicide prevention programs [23].

In this paper, we present the design and development of a computational platform with the aim to support the identification and prevention of suicidal behaviours. The platform is composed of two main components: **(i) a clinical decision support system** to help specialists with the screening, treatment management, and the collection and analysis of suicide-related data for surveillance purposes; and **(ii) a mobile-based application** addressed to people identified with suicidal behaviours (ideation, planning or attempt) to support the detection of risk factors and offer activities that can prevent the occurrence of these behaviours.

The platform was developed in the context of a collaborative research project with specialists (psychiatrists, psychologists, epidemiologists and public health managers) from the public health sector to facilitate its adoption in different primary care and specialised health services. The rest of the paper is organised as follows: Sect. 2 summarises some related work in the use of new technologies for suicide prevention. Section 3 presents in detail the design and main functionalities of the developed computational platform. Finally, Sect. 4 presents some conclusions and the ongoing and future work to evaluate the proposed platform.

2 Related Work

In the last years, several ICT-based solutions have been developed to support the prevention of suicide including informative websites, online self-help interventions, electronic therapy (e-therapy) interventions, interactive websites (chats), Internet forums, social networks, apps and video-games. Some of these applications are addressed to help health-care professionals with different activities during patients' suicide risk identification and intervention; some others are addressed to provide direct guided or unguided self-help to individuals in risk; and some others are addressed to involve relatives, family, gatekeepers and general public to increase the level of awareness of the suicide phenomenon [21].

Due to the evidence that a correct and early identification of individuals in risk contributes to enhancing treatment referrals and intervention [9,25,27], there are some current efforts in the development of computer-based systems for the screening of suicide risk and provider follow-up actions. For example, in [8] the authors describe the implementation of a computerised screening of suicidal ideation for youths in a paediatric primary care. A total of 1,547 youths responded to the system and 209 were identified with suicidal thoughts in the previous month. After a deeper mental health evaluation, 71 received a mental health service within 6 months. These results proved the feasibility of ICT-based screening in paediatric primary care, and the youth willingness to disclose suicidal ideation on a computerised screen.

More recently, the study presented in [6] describes the implementation of adolescents suicide screening and follow-up recommendations to providers into an existent clinical decision support system (CDSS) in primary care. In a sample of 2,134 patients, the system screened positive in suicidality over the 6% of them, and providers documented follow-up actions for 83% of patients screened positive. A similar ongoing study is presented in [15], where the authors describe a

protocol for the development of an electronic CDSS to support general practitioners in the identification, assessment and management of suicidality in primary care.

Another key aspect for the design of improved suicide prevention strategies is the collection and analysis of all the data that helps to better understand this phenomenon. Surveillance systems should be used to register not only suicide cases but also suicide attempts and self-harm situations. The analysis and dissemination of these data can help public health professionals and policymakers in the implementation of preventive actions [43]. Most of the current efforts in the collection and analysis of suicides, attempts and self-harms for surveillance purposes involves the integration of the electronic records obtained from independent ICT health systems, usually form the emergency department. Examples of these surveillance systems include the data repositories implemented at regional [12,39], national [28] and international [16] level containing the anonymised and merged collected records.

In addition to the development of ICT-based solutions addressed to directly support health-care professionals and policymakers, the new technologies also offer opportunities to provide *digital interventions* to individuals at risk through online programs and mobile applications. This kind of interventions helps to reach a larger population that currently cannot or does not get as much access to mental health services as required due to costs, logistical issues, stigma or convenience. Moreover, such interventions have the potential to improve the scalability of effective treatments for self-harm and suicidal ideation [2].

Examples of these digital interventions include an internet-based program to reduce suicidal ideation, depression and hopelessness among students of secondary school [31]; a mobile app for suicide prevention in Australian indigenous youth [38]; a web-based cognitive behaviour therapy intervention for the prevention of suicidal behaviour in medical interns [10]; an online preventive suicide intervention for adolescents [14]; and a mobile app for the reduction of suicidal self-injury [7], to name a few. A deeper review of these and other similar digital interventions can be seen in [45]. In general, the use of these tools for the decreasing of suicidal ideation and self-harm may be more effective than waitlist control, though it remains unclear whether these reductions would be clinically meaningful. Nevertheless, the effectiveness of these technological solutions seems to be the next field to explore in the coming decade [46].

In the next section we describe a computational platform that implements three of the features described in the above described technological solutions: *(i)* a web-based application to support with the ***screening*** of individuals with suicidal behaviour and ***follow-up actions***; *(ii)* a component for the analysis and visualisation of the collected data for the ***surveillance*** of suicidality; and *(iii)* a mobile application based on cognitive behaviour therapy to provide ***self-help interventions*** to prevent and detect suicidal behaviours.

3 The Computational Platform to Support Suicide Prevention

The proposed computational platform aims to contribute at different stages of the suicide prevention process, from the identification and screening of individuals with a suicidal behaviour to the support in the management of the provided treatment and follow-up actions. Two main modules were designed as the basis of the platform:

- A web-based **clinical decision support system (CDSS)** to help health-care professionals with:
  - The implementation of a standardised screening protocol.
  - The decision support in primary care for referring the patient to specialised services according to the results from the screening.
  - The implementation of a patient electronic psychological record to support with the management of the provided treatment.
  - The analysis and visualisation of the collected information for surveillance purposes.
- A **mobile-based (HelPath)** application to support patients with:
  - The collection and recording of relevant data that can be used to better assess their evolution.
  - The offering of suggestions and activities based on cognitive-behaviour therapy that can help to manage their current state.
  - The detection of factors that can be associated with a risk of suicidality.
  - Facilitate direct contact with the health-care providers and/or relatives in case of risk.

The CDSS can be deployed in both, primary care centres and in centres with specialised (psychological and psychiatric) health-care services. According to the role of the user (general practitioner, mental health specialist, epidemiologist or public health specialist), different functionalities are provided. All the information collected in each health-care centre, as well as some of the data collected through the patient's mobile application are stored in the central offices of the public health-care services. Figure 1 presents the main components of the platform. In the following sub-sections, each of the main features provided by the CDSS and the mobile application is explained.

3.1 The Clinical Decision Support System

Screening. When an individual seeks for help at the first time due to symptoms associated with some affective disorder, many times this first contact is with a general practitioner in a primary care centre. The patient usually does not identify what is the origin of the problem and is the clinician who has to identify whether the patient would need the provision of the mental health services. In the cases when the general practitioner identifies thoughts or ideas related to

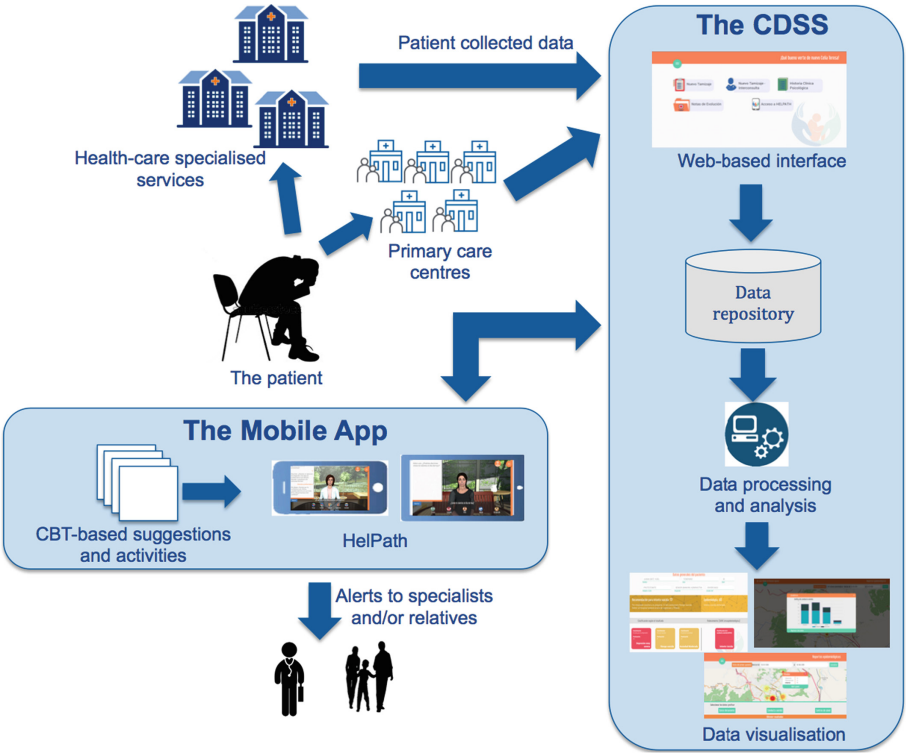


Fig. 1. The main components of the ICT-based platform to support suicide prevention.

suicidality, many times the patient is referred with "depression" to the mental health specialist. Nevertheless, in most of the cases, this assessment is not the result of applying a standardised instrument to diagnose a specific affective disorder leaving this task to the mental health specialist. In order to support a better assessment of the individuals that attend to primary care with this kind of problems, our CDSS implements an electronic version of three validated instruments used to identify different mental health disorders. The selection of these instruments was agreed with the clinicians of the project taking into account that are straightforward to apply by general practitioners in the primary care centres, and that most of the mental health professionals from the specialised centres are familiarised with these questionnaires.

The first instrument is the Calderon Depressive Syndrome Scale [4] which has been validated in the Mexican population [22]. The questionnaire consists of 20 items measured with a Likert type scale and depending on the responses, the individual can be diagnosed as non-depressive/with incipient depression/with middle depression/with severe depression. The second questionnaire implemented as part of the screening process is the Spanish validated version [33] of the Plutchik Suicide Risk Scale [29]. This scale contains 15 self-report items that should be

answered with "yes" or "no" describing the degree to which an individual reveals characteristics similar to those of a suicide prototype. The obtained total score range of 0–15 indicates no suicide risk (0–5); suicide risk (6–9); and high suicide risk (>10). The third questionnaire is the Hamilton Anxiety Rating Scale [11] implemented in its Spanish validated version [17]. The scale consists of 14 items, each defined by a series of symptoms, and measures both psychic and somatic anxiety. Each item is scored on a scale of 0 (not present) to 4 (very severe), with a total score range of 0–56, where <17 indicates mild severity, 18–24 mild to moderate severity, 25–30 moderate to severe, and >30 severe to very severe. These three questionnaires are administered to the patients after the requesting of some personal and sociodemographic data.

In addition to the results obtained from each questionnaire, it is important the assessment of whether the individual is presenting a specific suicidal behaviour such as ideation or planning. Thus, following the clinicians' advice, when the patient answer affirmatively any of the questions related with suicidality (i.e. question number 19 from the Calderon Depressive Syndrome Scale "Do you feel a desire to be dead?"; questions number 13 "Have you ever thought about committing suicide?" or 14 "Have you ever told anyone you would commit suicide?" from Plutchik Suicide Risk Scale), then the system asks the question "Have you think how to do it?". If the patient responds "no", then the patient is assessed as an individual with *suicidal ideation*. On the other hand, if the response is affirmative, the system asks for an input describing how the patient has thought to do it. In this latter case, the patient is assessed as an individual with *suicidal planning*.

Depending on the obtained results from the three questionnaires, the CDSS implements a rule-based inference system to suggest the referral of the patient to the mental health services either to receive psychological or psychiatric attention. When an individual is admitted in the emergency department of a hospital due to a suicidal attempt, once the patient is stabilised and out of danger, the clinician performs the interview to enter into the system the patient's data and the results of the questionnaires. Moreover, the *suicidal attempt* behaviour is recorded jointly with the used self-harm method according to the WHO's International Classification of Diseases, ICD-11. All this information collected during the screening stage is then available to the mental health specialists to decide the specific actions during the follow-up process.

Follow-Up and Treatment Management. Once the patient is referred to the mental health services, the psychologists or psychiatrists responsible for the follow-up actions can easily access the patient's data collected in primary care. At this point, the specialist can complete all the information required in the electronic psychological record. The required data include the patient's family background, his/her school and occupational history, information about family and friends networks of support, among others. During this stage, the specialist can take the decision whether the patient is suitable for the use of the HelPath App as a complement of the treatment. If HelPath is recommended, some of

the data stored in the patient's psychological record are then used by the mobile application as indicators to better assess further risks of suicidality (see Sect. 3.2). Moreover, all the information collected by the mobile application is also stored in the electronic psychological record for the specialist can observe the evolution of the patient's condition according to some factors such as the self-reported mood, negative thoughts or irrational beliefs, and physical or social activities.

As a complement to the patient's continuous self-reported information collected in the HelPath App, there is also the option that the specialists can apply again any of the validated instruments to get more data about the evolution of the patient's condition. Thus, through the CDSS's treatment management module the specialists can administer to the patient any of the three selected questionnaires used during the screening stage. This will allow the generation of plots to easily visualise the scores obtained at different times from each scale. Also, the system was designed to smoothly add other validated instruments for those specialists that want to use additional scales during the treatment of the patient.

Surveillance. As defined in [43], the registration not only of suicides but also of suicide attempts can add valuable information for the design of suicide prevention strategies. Having the records about suicide attempts and self-harm available to perform data analyses, e.g. on demographic and clinical risk groups is fundamental for the development, implementation, and evaluation of suicide prevention programmes [5]. Thus, our CDSS implements a surveillance module where all the information collected during the screening stage can be analysed and visualised in terms of different sociodemographic variables that each health professional can define in the user interface. As previously explained, all the suicide attempts received by the emergency departments can be registered including the used self-harm method. This information is also complemented with the recordings of all the individuals identified with suicidal ideation and planning.

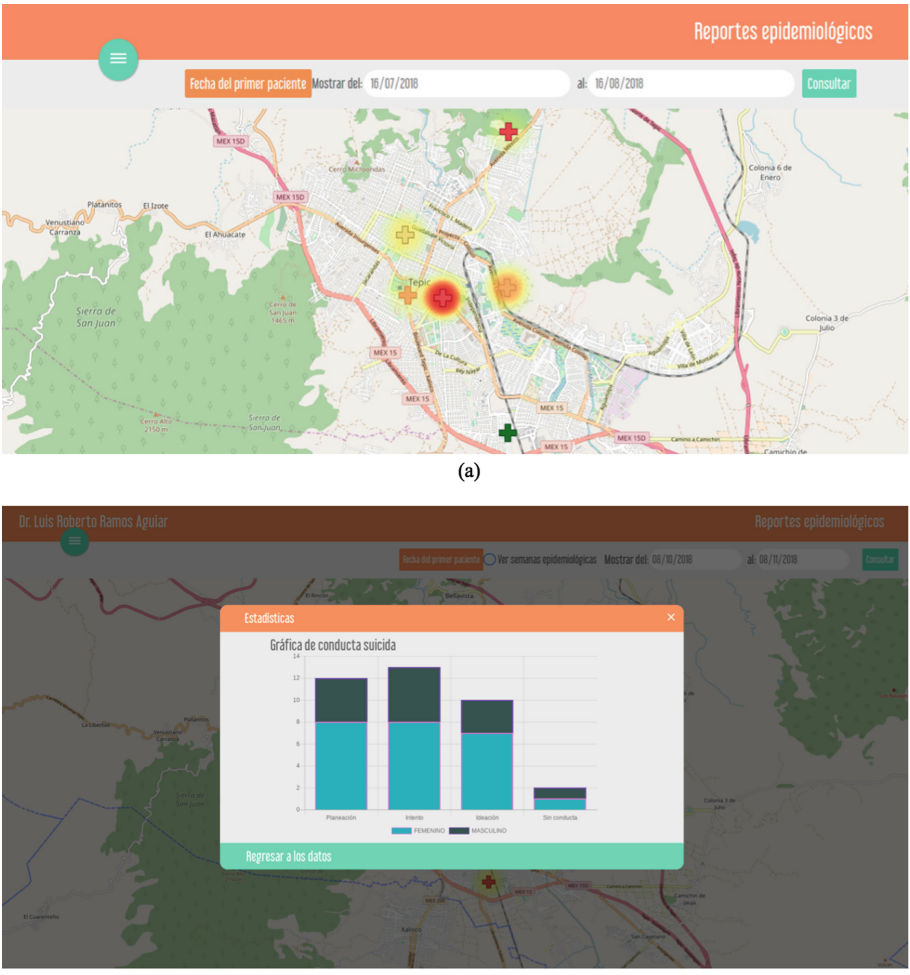
Our CDSS's suicidality surveillance module implements the processing and visualisation of the data collected in all the primary care and specialised services according to the different filtering parameters that can be defined in the user interface. Moreover, all the cases related to the different suicidal behaviours are georeferenced according to the location of the health care centres where those cases were detected. Using a city map (or state or the whole country maps) the visualisation of the number of cases can be easily identified through a heat map layer representing with different colours the quantity of detected cases related to suicide attempts, ideation and planning at each health care centre during a specific period of time (see Fig. 2(a)). Additionally, through the surveillance user interface different plots can be generated to identify incidence rates during specific time periods according to the gender, age, occupation, marital status among some others (see an example in Fig. 2(b)).

3.2 The HelPath App

There are currently several apps and web-based interventions with the potential to prevent suicidal behaviours through the provision of educational and support information; assessment of risk; facilitating the access to safety plans and the offering of crisis support [18]. A critical point of these applications is their ability to engage and motivate the users to promote their continuous and long-term use facilitating the effective provision of the information and support. One strategy to catch and keep the interest of the users is the use of Embodied Conversational Agents (ECAs) that act as virtual peers of the users to get information about the user's condition and to provide immediate feedback. The main characteristic of an ECA is the ability to emulate a person to person conversation through a combination of dialogue interaction represented in a human-like appearance with a set of body movements and facial expressions. In recent years the development and use of ECAs for suicide prevention have emerged acting as virtual counsellors to support individuals in risk, or as virtual patients for learning purposes where medical students, college or university teachers, or formal and informal caregivers are trained in the identification of clues associated with suicidal behaviours [19].

In our HelPath App, we developed an ECA as the main interface with the users. We have developed a set of four ECAs (two males and two females) for the users to choose -at the beginning of each session- their preferred ECA's appearance and clothes. The inputs from the user to the ECA are constrained to the selection of different options and values through the controls in the graphical user interface (see Fig. 3). We selected this solution to ensure data validity and accuracy, and to minimise errors in automatic speech recognition and natural language understanding, which is particularly important when designing health counselling interactive systems [3]. All the verbal responses from the ECA to the user are communicated via voice using the text-to-speech of the mobile device. The main functionality of the ECA is the collection of relevant data from the patient and the provision of suggestions and activities, based on Cognitive Behaviour Therapy (CBT), during short daily sessions. Another important functionality of HelPath is the identification of risk factors associated with a suicidal behaviour inferred from the patient's reported data and validated with a suicidal scale. In these cases, the app sends an SMS alert to the specialists or patient's relatives promoting a direct face-to-face contact.

CBT for Suicide Prevention. Different studies have shown the evidence about the use of CBT in the reduction and prevention of suicidal cognitions and suicidal behaviours, and that better patient outcomes arise when this type of therapy is focused on these suicidal cognitions and behaviours as dysfunctional individual factors rather than symptoms of mental illness [20,37]. Thus, we have implemented five modules based on principles of the CBT in our HelPath App where the ECA is responsible for offering most of the content and motivating to the user in the execution of the recommended activities. The five modules are the following:



(a)

(b)

Fig. 2. (a) A heat map for the visualisation of suicidal behaviour (ideation, planning and attempt) cases detected in the different health care centres from a city. (b) Generation of plots with the information of suicidal behaviour cases divided by gender.

1. An initial psychoeducation activity.
2. The emotions and mood monitoring.
3. Cognitive modification.
4. Behavioural activation.
5. Relaxation techniques.

Psychoeducation. An important initial phase of a CBT-based intervention is to dedicate some time to explain the patients about their symptoms, describe an explicit conceptualisation of the problem, introduce the basic principles and

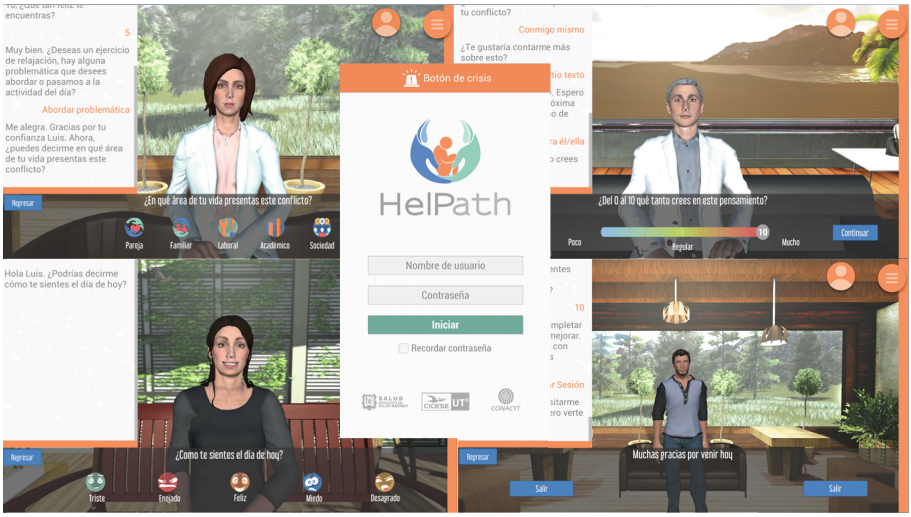


Fig. 3. The different ECAs of the HelPath mobile application.

goals of CBT, and how it can help them [36]. So, the first time that the patient enters into HelPath, a psychoeducative video is played where a combination of cartoonish images in movement with a narrator explaining the main components of the CBT including some cognitive, emotional and behavioural factors and how they are related with a dysfunctional condition. In subsequent sessions, the patient can access the video at any moment through the main menu of HelPath.

Monitoring of the Emotional State. A key element in CBT is to support the patient with the ability to be self-aware and reflective of his/her emotional states, thoughts and behaviours. A useful strategy -for both: the clinician and patient- is to maintain a constant monitoring of these elements to understand better how they are interrelated and influenced. In HelPath, the first activity after the ECA's welcome is to ask the patients about their feelings. The ECA questions about what emotion is the patient feeling today and the GUI offers five basic emotions (sad, angry, happy, disgust and fear) and the "none of these" option for the patient makes a selection. Once the emotion is selected, the ECA asks the user about the intensity of that emotion offering a slider for the patient to select a 1–10 value. When the patient does not select any of the five basic emotions, the ECA asks "How is your mood today?" and the patient responds by using a slider representing values from bad to good mood. The self-reported emotions/mood and their intensities are stored for the further assessment of the patient's condition and for the summary reports that are integrated into the patient's electronic psychological record.

Cognitive Modification. HelPath supports patients with cognitive modification by implementing some activities based on the *ABC-DEF* framework of the

Rational-Emotive Behaviour Therapy - REBT (a particular form of CBT) [34]. The first part, the *activating event (A)*, starts when the ECA asks the area (family, work, academic, social or partner) where the patient could identify a possible conflict. A second question is to detect if the conflict is with him/herself, with others or with life. After that, the ECA offers the possibility for the patient enters text to describe the conflict. This information is used to categorise the (irrational) *belief (B)* allowing the ECA to offer a set of 5–7 irrational beliefs (IB), according to the selected area, for the patient to choose the one more related with the conflict. To identify the -emotional- *consequences (C)* of the IB, the ECA asks about how much the patient beliefs in the selected IB and what is the emotion elicited by it.

Once identified the *ABC* of the conflict, the ECA implements the *disputation (D)* of the IB by asking three questions. The first one is about the evidence the patient has on that IB. The second is about how much the patient considers useful the IB, and with the third one, the ECA guides the patient towards thoughts' flexibility by requesting some other explanation to the IB. After the patient's responses, the ECA provides an alternative (rational) belief trying that the patient replaces the IB by an *effective (E) new belief*. Finally, to promote the co-construction of more *functional (F) emotions and responses*, the ECA suggests the execution of an activity related to the offered rational belief to practice and reinforce it. Moreover, the ECA asks about what the patient has learned, how much believability the patient now has on the original IB and whether there was some change in the original reported emotion or mood. All this information is used for the assessment of a possible cognitive change in the patient.

Behavioural Activation. A complementary strategy to the cognitive change is the promotion of activities that help patients to develop protective factors against suicidality risks. The behavioural activation focuses on activity scheduling to encourage patients to approach relevant and satisfactory activities [40]. Thus, the ECA offers a set of activities to schedule a maximum of five during the current week aiming to get a commitment from the patient. The activities are divided into two categories: those directed to develop personal and social abilities (such as interpersonal relationships, self-discovery or conflict resolution); and those for activation such as sports, movies, art, nature, or religion among some others. Once the week's activities are set, HelPath sends reminders highlighting the importance to execute them and offers the option to re-schedule those activities not reported as performed on the planned day. When the deadline of each activity arrives, the ECA questions the patient whether he/she performed the activity, what were the obstacles faced during its (no) execution, and for the cases of the executed activities, what was the obtained satisfaction level.

Relaxation Techniques. The relaxation is one of the procedures that have benefits to a variety of mental health problems. The main goal of relaxation is to reduce the physiological activation produced by stressful events, facilitating the recovery of a well-being state. HelPath offers the patient with four relaxation exercises.

Two of these exercises are based on Jacobson's progressive muscle relaxation exercises (PMR) involving muscle tension and relaxation [1]. The other two exercises are based on controlled and deep-breathing relaxation techniques. The ECA explains the content and objective of each exercise, and when the patient selects one, a video with a pre-recorded voice guides the patient through the exercises while some images are displayed on the screen. After the exercise is finished, the ECA asks the patient about his/her current emotional state. If the patient reports a negative emotion with a higher intensity than the reported at the beginning of the session, the ECA offers another relaxation exercise, a cognitive modification exercise to identify the possible conflict, or suggests the calling to a contact person.

Suicide Risk Detection. The prediction of suicide in a person is difficult due that individual risk factors account for a small proportion of the variance in risk and lack sufficient specificity, which results in high rates of false positives [24]. Individual assessments need to be done to identify if suicide risk is present by recognising personal protective and risk factors. Then if suicide risk is present, further assessment should address the imminence of suicidal behaviour [13]. Using the information collected during the screening and the filling of the electronic psychological record stages, and some of the self-reported information through HelPath, some risk factors associated with suicidal behaviour are identified taking as reference the SAD PERSONS scale [26]. If risk factors are detected, the Roberts' Suicide Ideation Scale [30] is applied to assess the imminence of suicidal behaviour and to minimise the occurrence of false positives. Depending on the results, alert messages are sent to pre-defined contacts promoting direct face-to-face support.

The SAD PERSONS Scale. This scale consists of 10 items (each one corresponding to each scale's name letter) assessing a risk factor for suicide: *S*ex, *A*ge, *D*epression, *P*revious attempt, *E*thanol abuse, *R*ational thinking loss, *S*ocial supports lacking, *O*rganised plan, *N*o spouse, and *S*ickness. Each factor is scored as 1 if present or 0 if absent, resulting in a cumulative score that is interpreted as conveying a specified level of risk. In HelPath The assessment of the patient through SAD PERSONS is triggered when any of the following conditions occurs:

1. **Drastic or sudden changes in the emotional state.** These changes are identified when the patient reports a high positive emotion/mood during three or more consecutive sessions, and then he/she reports a high negative emotion/mood. Also, if during the same session the initial emotion reported is highly positive but after the execution of some suggested activity the patient reports a high negative emotion, the scale is applied.
2. **Suicidal thoughts.** When the patient selects any of the irrational beliefs categorised as hopelessness, negative views about self, verbalisation about dead, or possibilities to commit suicide.

3. **Cognitive rigidity.** Identified when the patient reports a high level of believability on any IB, even when the ECA has offered an alternative rational belief.
4. **Recurrent negative thoughts.** When the patient selects three or more consecutive times the same IB, but not classified in any of the categories of the above point 2.
5. **Difficulties in the execution of planned activities.** When the patient reports three or more consecutive times that he/she found obstacles to execute the planned week activities, independently whether the activities were reported as completed or not completed.
6. **Vulnerability to stress or adverse events.** When the patient reports a high negative emotion/mood, he/she performs a relaxation exercise, and the reported emotion/mood after the exercise is still highly negative.

When any of the six above conditions is fulfilled, HelPath internally assesses whether the patient can be considered within a high-risk population through the SAD PERSONS scale considering a score equal to or greater than 7. Nine of the ten items of the scale are obtained from the electronic psychological record and the results of the screening questionnaires. The only item obtained from the patient interaction with HelPath is the *rational thinking loss*, by assessing the irrational beliefs selected by the patient using the same condition explained in the above point 2. If the patient is assessed within the high-risk population, then the Roberts' Suicide Ideation Scale is applied to assess the imminence of suicide and to minimise the false positives. The only condition to apply the Roberts' scale without considering the results of SAD PERSONS is when the patient selects any of the IB related with verbalisation about dead.

The Roberts' Suicide Ideation Scale. This scale, validated in Mexican population [32], consists of four items regarding thoughts about death and taking one's own life over the previous seven days. The items include *"thoughts about death"*; *"family and friends better off if I were dead"*; *"thought about killing myself"*; and *"would kill myself if I knew a way"*. A four-point scale is used with the options: 0 = 0; 1–2 days = 1; 3–4 days = 2; and 5–7 days = 3. The overall score ranges between 0 and 12 points. In HelPath, when the Roberts' scale is applied the assessment of a high-risk situation results from a score equal to or greater than five points. In these cases, the HelPath app sends an SMS to the patient's contacts (defined by the patient in the settings of the app), recommending to make a call to the patient. Moreover, if the patient authorises and the GPS is activated, the SMS includes the location of the patient to facilitate direct contact. In the app, the ECA also suggests to the patient to make a call and put the mobile phone in a call mode showing his/her contact numbers including the crisis line number, and then finishes the current session.

For those cases when the score of the Roberts' scale is lesser than five, the ECA suggests the patient make a call looking for social support. In these cases, no alert messages are sent and the session can continue and finalise normally. It is important to mention that as a complement to the mechanism for the automatic

detection of suicidality risk, HelPath also implements a *crisis button* which is accessible from the app's menu or the login screen (see Fig. 3). When the patient pushes this button, HelPath shows the list of the pre-defined contacts for the patient to select the person to make a call. When the patient selects the specific contact, the mobile phone is put on call mode, and at the same time, the alert messages are sent to the whole list of contacts. In this way, we try to minimise the risk that the patient's selected contact is not available to answer the call and warn about the situation to the other pre-defined contacts.

4 Conclusions and Future Work

Suicide is a complex phenomenon that requires the collaboration of different disciplines and sectors to guide the implementation of effective preventable strategies. One of the disciplines that have the potential to contribute to the design and deployment of effective prevention strategies is the ICT. Different computer-based applications have been developed in recent years as technological tools to support diverse suicide prevention activities, from the screening of individuals in risk to the provision of self-help interventions. In this paper, we have presented the development of a computational platform composed of two main modules: a Clinical Decision Support System to help health-care professionals, and the HelPath mobile application to monitor and support individuals in risk.

The design and development of the two components were developed in close collaboration with health care specialists to facilitate their use and adoption by the clinicians at both, the primary care and specialised health care centres. The deployment of this platform to perform an initial evaluation is ongoing, and it includes the participation of four primary care centres and two centres with specialised mental health services. All these public health care centres are coordinated by the local Government of Nayarit's region in Mexico that can facilitate the addition of new centres in the near future. The initial set of testings include the assessment of the CDSS's usability and functionality to detect corrective and improvement actions according to the feedback obtained from the users with the different roles in the system, such as general practitioners at primary care, specialists (psychologists and psychiatrists), clinicians at the emergency department and epidemiologists.

Additionally, we are currently finalising a first pilot study to evaluate the usability and acceptability of HelPath. We recruited a total of 18 participants with antecedents of suicidal ideation, planning or attempt but excluding in this first pilot, for safety reasons, those individuals with recent (during the last six months) suicidal behaviour. The participants, under the supervision of a specialist, were asked to use HelPath for two months suggesting them to carry out a daily interaction. The objective of this initial study is to get qualitative and quantitative data about the use, acceptability, usability and adherence level from the user towards the app as a whole, towards the appearance and behaviour of the ECA, and towards the CBT-based contents provided by HelPath. At this

moment, we are starting to collect and analyse the data provided by the participants. The details of the HelPath's pilot design, the evaluation protocol and the obtained results will be further reported.

In the mid and long term, when the platform has been deployed in the different healthcare centres, the expected outcome from both components is to support the clinicians with a better understanding of the different (e.g. sociodemographic, contextual, environmental, etc.) factors associated with suicidality. The nurturing of the central data repository with the information from the people detected and treated, would allow the further implementation of data mining techniques for the recognition and assessment of different patterns associated with these factors. Moreover, the platform will contribute to getting a better picture not only of the suicide cases (which is the focus of current surveillance systems) but also of the different suicidal behaviours (ideation, planning and attempt) that occur in a more significant number.

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