A Telemedicine Application for Remote Diagnosis and Assessment of Mood Disorders

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Abstract. Depression in its various forms is a widespread phenomenon in modern societies. Its high prevalence, associated costs, the chronic nature it develops and the challenges in diagnosing it put a lot of pressure on public healthcare systems. In response to these challenges, ICT-based approaches are increasingly implemented to support effective patient management and discovery. This paper presents a web application named "feeldistress", which is based on a novel distress evaluation framework to enable remote diagnosis of anxiety and depression, facilitate continuous evaluation of patients and assist prevention of suicide. The developed application was used and evaluated from a qualitative perspective by 117 students (47% women) who had visited the Special Office for Health Consulting Services of the University of Patras between 2014 and 2017. The majority of the users were very satisfied by the functionality, usability and appearance of the application showing it can be extremely useful tool for someone before hitting the door of a mental health specialist.

Keywords: Telemedicine · Mood disorders · Remote diagnosis

1 Introduction

Depression in its various forms (major depression, dysthymia, depressive phase of bipolar disorder) is a widespread phenomenon in modern societies that causes significant level of disability. Depressive people experience various emotional, physical, cognitive and mobility problems, including negative beliefs about themselves and intense pessimism about the present and the future, diminished mood, unwillingness to

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take any deliberate action and suicidal ideation or suicidal behavior. They often report that their mind is confused and their thoughts are slow, and that they have difficulty restraining information or solving problems [1]. Apart from the negative impact depression has on a personal level, it also affects society as a whole (e.g. job withdrawal and low productivity) and accounts for significantly increased financial cost to all involved stakeholders (i.e. patients, health systems, social security, etc.), mainly because of its intense and persistent consequences, the recurrent characteristics and its under-treatment in all walks of life [2, 3]. Studying eight countries that differ in cultural characteristics and GDP, researchers from the London School of Economics and Political Science (LSE) reported that depression costs a total of more than 220 billion euros a year to Brazil, Canada, China, Japan, Korea, Mexico, South Africa and US [4]. The results of their investigation carried out among 8000 officials working in these countries, showed that the US (EUR 75.5 billion) and Brazil (EUR 56 billion) have the highest rates of loss of productivity due to the systematic presence of employees suffering from depressive symptoms. Concerning European citizens, approximately 5% of them have clinical depression, and it is estimated that 17% will experience significant depression at some point in their lives [1].

It is widely known that timely diagnosis of depression enables early treatment, which could be critical in terms of its scaling and intensity [5]. However, diagnosis of this severe mental illness and its forms is hindered by several subjective (e.g. inability to reach an experienced health provider) and objective (e.g. lack of quantified clinical tests) problems. Unfortunately, depression is significantly underdiagnosed or misdiagnosed and subsequently undertreated, particularly in the primary care environment. Although more patients are seeking help and utilization of antidepressants is on the rise, the level of treatment is inadequate [6]. An indicative research resulted that in the primary care setting, people with depression received a correct diagnosis less than 50% of time [7]. Likewise, African Americans who suffer from depression experience frequent underdiagnosis and inadequate management in primary care [8]. In general, a wide range of subjective factors is acknowledged by the literature to account for this diagnosis and treatment shortfall, which is even bigger in rural areas, such as stigma, distance between people living in remote locations (e.g. islands) and medical experts, limited resources, lack of adequate mental health professionals and services. In addition, depression often co-exists with other mental problems such as anxiety disorders, a situation that also puts barriers to early diagnoses of depression [9].

The above and other data show the high prevalence of depression, its associated costs, the chronic nature it develops and the challenges concerning the critical task of diagnosis. As a result, a lot of pressure is been put on public healthcare systems highlighting the need of new models to offer adequate support to depressive patients. Assisting depression diagnosis and management in primary care could induce faster and more accurate diagnoses, enabling a timely and more precise intervention to great advantage of both patients and health systems. To this end, various researches and initiatives in the field of Health and Education for integration, social inclusion and support for people with mental illness have shown a growing interest in exploring the use of Information and Communication Technologies (ICT) to support effective patient management and discovery. ICT-based solutions are indeed showing great potential in supporting all the stages of care provision to patients with depression improving access

to healthcare services, delivering faster and better care to patients, enabling continuous patient monitoring and automatic assessment, providing risk prediction and delivering personalized feedback provisioning services among others.

In this context, this paper presents the preliminary validation data of an online tool that enables remote diagnosis of anxiety and depression, facilitates continuous evaluation of patients to assess illness progress and response to followed treatment and assists prevention of suicide. The developed web application named "feeldistress" incorporates a novel distress evaluation framework that integrates a combination of weighted questionnaires provided in a specific sequence according to users' replies. As the users fill the questionnaires, the application provides feedback based on the scores of their replies in each questionnaire, in order to inform them of their health status and suggest appropriate actions.

2 Related Work

The use of ICT and, more specifically, the role of telemedicine in psychiatry has been subject of research for many years. Telepsychiatry mainly employs synchronous video consultation and is an increasingly common method of providing psychiatric care at a distance in response of various major limitations in care delivery (e.g. distance, transportation cost, lack of local expertise, etc.). Ruskin et al. [10] examined 119 depressed veterans referred for outpatient treatment in three US clinics, who were randomly assigned to either remote treatment by means of video-based telepsychiatry or in-person treatment to compare treatment outcomes of the two approaches over a 6-month psychiatric treatment. Patient evaluation using the Hamilton Depression Rating Scale (HDRS) and the Beck Depression Inventory (BDI) showed that telepsychiatric therapy was as effective as facial treatment in terms of symptom improvement.

A major category of ICT solutions consists of mobile, wearable and pervasive health systems. These systems are more sophisticated, complex and agile than conventional telemedicine systems enabling constant patient monitoring through various sensing devices and employing real-time data analysis, in order to assist diagnosis, patient management and treatment support. Joshi et al. [11] developed a multimodal framework to fuse audio and video data for depression diagnosis, which could analyze intra-facial muscle movements and movements of head and shoulders, in conjunction with audio signals through various fusion methods. Other systems, such as the ICT4D [12] utilize wearable biosensors for activity monitoring and measurement of various electrophysiological indicators and apply data analysis algorithms to reason about the state of depressive patients and the risk of a potential relapse. Based on the induced information ICT4D provides appropriate feedback via mobile phone and the web.

Another important category of ICT-enabled approaches exploit the Internet to deliver various eHealth and telemedicine services through web-based applications. Adriana Mira et al. [13] developed an Internet-based program to teach adaptive ways to cope with depressive symptoms and daily problems. 124 participants who were experiencing at least one stressful event that caused interference in their lives, many of whom had clinically significant depressive symptoms, were randomly assigned into one of the following three groups: (1) intervention group with ICT support (automated

mobile phone messages, automated emails, and continued feedback), (2) intervention group with ICT support plus human support (brief weekly support phone call without clinical content) and (3) a waiting-list control group. The constructed treatment protocol was adapted to a completely self-help Internet-based, multimedia (video, image, etc.), interactive application designed for optimal use on a personal computer. Analysis of a 12-month usage of the Internet-based program showed that it was effective and well accepted, with and without human support, resulting in a significant improvement pre- to posttreatment, compared with the control group.

Farvolden et al. [14] developed Web-Based Depression and Anxiety Test (WB-DAT), a freely-available, web-based, self-report screener for major depressive disorder and anxiety disorders. This web-based diagnostic tool was administered to 193 subjects who presented for assessment and/or treatment in research projects that were conducted at the Mood and Anxiety Program and Clinical Research Department at the Centre for Addiction and Mental Health in Toronto, Ontario, Canada. Preliminary data from the comparison between WB-DAT and conventional clinical assessment tools suggested that WB-DAT was reliable for identifying patients with major depressive disorder and various anxiety disorders.

In our study, we focus on the development and implementation of a web application for remote diagnosis and assessment of individuals that feel distress, anxiety and/or depression symptoms. This tool is based on an innovative distress evaluation framework that considers a specific sequence of multiple scales, in contrast to existing approaches that use individual scales, which are mainly applied to assess a medical process than provide a diagnosis. Thus, it considers multidimensional data to create a more integrated clinical view and achieve a more accurate and multifaceted diagnosis while recommending the most appropriate actions to be taken.

3 Tools and Methods

3.1 Distress Evaluation Framework

As described in the previous sections, our approach integrates a combination of questionnaires, which consist of the Hospital Anxiety and Depression Scale (HADS), the State Trait Anxiety Inventory form Y (STAIY), the Beck Depression Inventory (BECK) and the Risk Assessment Suicidality Scale (RASS). HADS was developed by Zigmond and Snaith in 1983 [15] and is commonly used by physicians to determine the levels of anxiety and depression of a person. The HADS is a fourteen item scale that generates ordinal data. Seven of the items relate to anxiety and the other seven relate to depression. Each item on the questionnaire is scored from 0-3 and this means that a person can score between 0 and 21 for either anxiety or depression. Bjelland et al. [16] identified a cut-off point of 8/21 for anxiety or depression. For anxiety (HADS-A) this gave a specificity of 0.78 and a sensitivity of 0.9. For depression (HADS-D) this gave a specificity of 0.79 and a sensitivity of 0.83. We used the Greek version of HADS [17], which shows a high internal consistency and validity, as well as good psychometric properties and can be proven in practice as a useful tool for clinicians to identify symptoms of anxiety and depression in primary healthcare.

The STAIY scale [18] was published in 1985 and consists of two strands, which calculate the State and Trait anxieties. State Anxiety (S-Anxiety) is the subjective and transient feeling of pressure, nervousness and anxiety at a given time, which can be is accompanied by activation of the autonomic nervous system. The Trait Anxiety (T-Anxiety) refers to the relatively constant individual differences with regard to the anxiety proneness, which they constitute personality trait. The scale for S-Anxiety consists of twenty statements that assess how the subject feels at the time the scaled is filled. The scale for T-Anxiety is also composed of twenty statements, but assesses how the subject feels generally. Ratings for both S-Anxiety and T-Anxiety range between 20 and 80 and studies in the Greek population showed that scores above 40 indicate potential mental health problems [19].

The Beck Depression Inventory (BDI) [20] is a multiple-choice self-report inventory, one of the most widely used psychometric tests for measuring the severity of depression. It contains 21 questions, each answer being scored on a scale value of 0 to 3. Higher total scores indicate more severe depressive symptoms. The standardized cutoffs are: 1–10 = normal fluctuation, 11–16 = mild mood disorder, 17–20 = marginal clinical depression, 21–30 = moderate depression, 31–40 = severe depression and >40 extreme depression. The Greek version of BDI has very good internal consistency and test-retest reliability, as well as high validity. The scale's good psychometric properties were confirmed for the Greek population, suggesting that its translation and adaptation to the Greek language yield a valid and reliable tool [21].

Risk Assessment Suicidality Scale (RASS) [22] was constructed as a self-report instrument with emphasis on the items that describe suicide-related behavior targeting assessment of suicidal risk in the general population as well as in mental patients. RASS consists of 12 items (with 4 possible answers – not at all, a little, quite enough very much) that estimate different views of suicidal behavior, by looking at intention and attitude towards life among others. The RASS is a reliable and valid instrument which might prove valuable in the assessment of suicidal risk in the general population as well as in mental patients.

By using and stepping through the sequential activation of the aforementioned questionnaires, someone feeling distress can quickly evaluate the symptoms of depression and/or the levels of anxiety, the suicidal ideation, or even check if there is a relapse of the disease in the past. The first step in our methodology is to fill the HADS scale (including HADS-A and HADS-D). Questions refer to marketing issues rather than physical problems (e.g. I feel anxious or terrified; I lost interest in my appearance). If the user scores more than 8 in the HADS-A scale (high level of anxiety) he/she is driven to the STAIY scale. STAIY evaluates the emotional state of the subject (transient stress as a result of the current situation). We want to know how the user feels right now, by answering questions such as "I feel calm," "I'm upset", which score range from 1 (not at all) to 4 (very much). Stress is proportional to the score on the scale, meaning that the higher the score on the scale, the greater the temporary anxiety, according to the aforementioned classification of STAIY (e.g. if the score is higher than 40, we have severe anxiety or panic attack).

If the score is more than 8 on the HADS-D scale (high level of depression) the user is driven to the BDI scale, a reliable tool for psychological assessment of depression and accurate measurement of its severity. The user is called to provide answers that best

describe how he/she feels over the past few days. Depending on the overall score in the BDI scale, the user should receive feedback suggesting actions to be performed. For instance, if the BDI score is above 17 for at least 2 weeks the user should seek specialist help. Special attention should be given to a BDI's question concerning suicidal tendencies, specific replies to which might suggest risk of suicide requiring immediate psychiatric help. In this case, as well as if the total score in the BDI scale is 17 or more, the user is driven to the RASS questionnaire that consists of 12 questions, such as "Do you fear that you will die?" and "Do you enjoy life?. RASS aims at identifying suicidal risks to inform users to immediately seek for psychiatric help.

3.2 Feeldistress Application

The "feeldistress" application (available at www.feeldistress.gr) was developed through a set of contemporary web technologies, such as PHP7, HTML5, Javascript and Ajax. For the needs of data storage a MySQL v10.2.12 was built. Initially, the user is required to register and during registration the user is called to provide several demographic data. These data include age, gender, family and occupational status, lifestyle, education, socio-economic status and some information about chronic illnesses, dealing with difficulties in everyday life (functionality), drug use or other substances. After registration and login, the user is able to start filling the scales based on the framework described in the previous section.

The first scale is the HADS and depending on the accumulative individual scores of HADS-A and HADS-D the application provides the STAIY and BDI scales respectively. If both STAIY and BDI are to be provided, STAIY is provided first and BDI is given after BDI is filled. Finally, based on the answers of the BDI scale, the application provides the RASS scale, which is shown in Fig. 1. Depending on the users' replies,

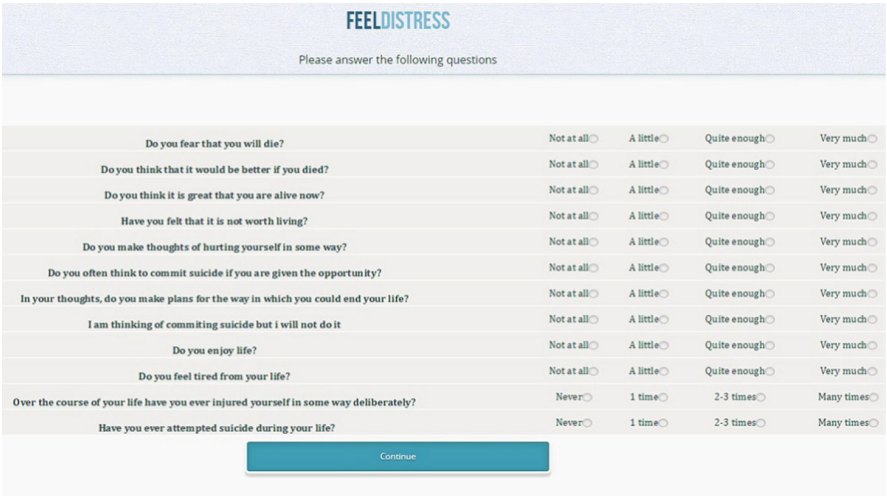

Fig. 1. The RASS scale in the feeldistress application.

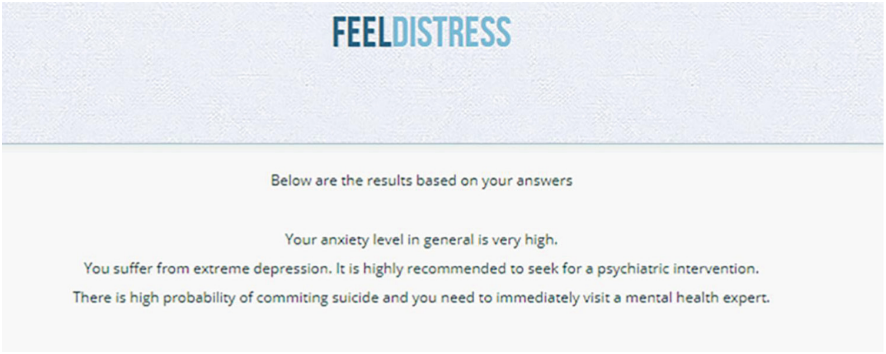

Fig. 2. Example feedback provided by the feeldistress application.

the application diagnoses and evaluates the level of depression they are experiencing and provides feedback by recommending appropriate actions (Fig. 2).

3.3 Experimental Setup

The developed application was used by 117 students (47% women) who had visited the Special Office for Health Consulting Services of the University of Patras between 2014 and 2017, because they felt distress due to anxiety or depression symptoms. The scope of the Special Office for Health Consulting Services is to diagnose mental disorders, manage interventions (psychiatric and psychotherapeutic) and provide psychosocial support to the students of the University of Patras.

These students had already filled the HADS, the BDI and the Beck Anxiety Inventory (BAI) in the academic years 2014 - 2017. Results of the HADS showed that 57% and 77% of the test sample suffered from depression and anxiety respectively. Based on the BAI results, 31.6% was experiencing moderate anxiety 32.5% mild to moderate anxiety and 29.1% severe anxiety. The BDI test revealed that 16.2% was suffering from extreme depression, 19.7% from moderate depression, 13.7% from severe depression and 14.5% from clinical depression.

Prior to using the application, all the test subjects had "psycho-diagnostic" interview by phone, to talk about their lives at that period and get informed of the feeldistress application. Subsequently, the students were invited to use this application via email, which included a short user guide and a consent form (requested to be signed and sent back to us before using the application) describing that their participation was for research purposes and they would not have any kind of gain by using it. In addition, the test subjects were given a questionnaire to qualitatively evaluate the application that was anonymously filled and sent back to us. This questionnaire consisted of 11 questions, 4 of which referring to demographics and 4 to the application in terms of ease of use, functionality, aesthetic and content reliability and utility. Potential answers were excellent, very good, adequate and poor. The final three were open questions: Which improvements would you suggest?; Would you recommend feeldistress to other users?; How often do you visit mental health related web pages and applications and for which reasons?

4 Results

In order to examine the relationship between the variables of the qualitative evaluation questionnaire and analyze its results, we used the Pearson correlation coefficient, the x2 independence test, One Way Anova, while Cronbach's alpha was used to measure the reliability of the questionnaire. Bases on the users' replies, all of them were satisfied by using the "feeldistress" application, which correlates with the fact that everyone would suggest it to others (100% of the sample participants would recommend the application to other users). Trying to relate the users' identified levels of anxiety and depression to how they evaluated the application, we did not receive any significant correlation (57% had depression and 77% anxiety).

Regarding ease of use, 82% of the participants (96 out of 117) consider "feeldistress" app as excellent and 12% very good. Combining these percentages with the answers to the open question "What improvements would you suggest", we've seen that some participants found difficult to locate unanswered questions at the point they have reached at the end of each questionnaire. Concerning functionality, 83.7% (98 out of 117) found "feeldistress" excellent and 13,6% very good, while aesthetic was largely considered as excellent (93%). Finally, in the case of content reliability and utility, 63% of the participants (74 out of 117) found them excellent, 27% stated they were very good and 8.5% adequate.

5 Discussion and Concluding Remarks

ICTs are increasingly explored and implemented in health and, more specifically, in mental health to support clinical practice and offer new capabilities in care provision and healthcare service delivery. The web application "feeldistress" aims at assisting depression diagnosis and treatment of depression mainly by enabling an initial remote health status assessment. Based on a multidimensional evaluation framework it creates an integrated health and mood profile to accurately evaluate anxiety and depression status and motivate users to contact a specialist if required. The developed application attempts a structured diagnosis of psychometric-treated therapy. The goal of psychometric techniques is to provide the specialist with the ability to develop a structured psychiatric assessment, i.e. to provide a skeleton, which helps him get the basic information required for diagnosis. Also with the psychometric tools there are concrete results, which classify the patients to specific norms, thus obviously facilitating the final diagnosis, the observance of objective statistical data and the research.

Results of the "feeldistress" app evaluation by people who had experienced anxiety discomfort or depression symptoms in the past showed that it can be an extremely useful tool for someone before hitting the door of a mental health specialist. The majority of the users were very satisfied by the functionality, usability and appearance of the application. This even more important if we take into account the fact that all of the users that frequently use mental health web pages and apps (31.6% of the users) were very positive with "feeldistress". As indicated by the users, a major improvement would be to utilize pop up messages to indicate unanswered questions more precisely.

This was the most frequent problem participants faced, which is completely rational considering the multitude of questions they are call to answer.

As this paper presented some preliminary results of the qualitative evaluation of the developed application, we plan to validate its usefulness through specific application scenarios (e.g. applied treatment assessment) and reveal meaningful hidden relationships among patient data elicited by the questionnaire filling. We also plan to use "feeldistress" as the basis to a more sophisticated portal that will include instructions and advice, online chat and teleconference capabilities to facilitate both synchronous and asynchronous communication between patients and physicians. We intend to add more features, such as mood recording and automatic mood chart creation and display to support a regular monitoring of patients and provide physicians with additional patient information.

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