

Innovative ICT solutions to improve treatment outcomes for depression: The ICT4Depression project

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Abstract. Depression is expected to be the disorder with the highest disease burden in high-income countries by the year 2030. ICT4Depression (ICT4D) is a European FP7 project which aims to contribute to alleviate this burden by making use of depression treatment and ICT innovations. In this project we developed an ICT-based system for use in primary care that aims to improve access as well as actual care delivery for depressed adults. Innovative technologies within the ICT4D system include 1) flexible self-help treatments for depression, 2) automatic assessment of the patient using mobile phone and web-based communication 3) wearable biomedical sensor devices for monitoring activities and electrophysiological indicators, 4) computational methods for reasoning about the state of a patient and the risk of relapse (reasoning engine) and 5) a flexible system architecture for monitoring and supporting people using continuous observations and feedback via mobile phone and the web. The general objective of the ICT4D project is to test the feasibility and acceptability of the ICT4D system within a pilot study in the Netherlands and in Sweden during 2012 and 2013.

Keywords. depression, self-help, eMental health, mobile phone, ICT

Introduction

Current treatments of depressive disorders, such as pharmacotherapy and psychotherapy, can reduce the burden of these diseases with about one third [1]. Most depressed patients are treated in primary care. However, the treatment options for general practitioners are limited. In most cases, general practitioners prescribe antidepressant medication, although the majority of patients prefer psychological

treatments [2]. Also, the general practitioner has only limited time for the patient. Therefore, current treatments for depression may be considerably improved using innovative ICT solutions. Meta-analyses demonstrated that internet-based interventions are effective for treating depression [3]. Some studies show promising results using mobile phones to improve treatment of depression [4]. However, these studies are scarce and include no other ICT solutions to improve treatment outcome apart from using Internet and mobile technologies.

In an EC funded project, called ICT4Depression (ICT4D), a system is developed aimed to improve the outcome of treatments for depression. This system supports (guided) self-help depression treatment in primary care via the internet and mobile phones. The therapies are integrated in an intelligent (self-)support system for patients suffering from depression. The aim of the project is to develop such a system and to study the feasibility and acceptability of it. The ICT4D system will be evaluated in a pilot study within a sample of 25 depressive patients in a primary care setting in the Netherlands and in a similar pilot study in Sweden. In this paper an overview is given of the different components of the ICT4D system.

Self-help treatments for depression

Treatment modules that have been developed, transformed and extended for this project are psychoeducation, behavioral activation, problem solving therapy, cognitive restructuring, exercise therapy, medication adherence, and relapse prevention. A description of each of the treatment modules is presented below.

Psychoeducation. A meta-analysis revealed that brief passive psychoeducational interventions for depression and psychological distress can reduce symptoms [5]. The psychoeducation module in the ICT4D project contains general information about (treatment of) depression, exercises about goal setting and will help patients to assess the severity of their problems. The severity of the symptoms, along with other criteria, will be used to give the patient an automatic advise about whether to start another treatment module and which one.

Behavioral activation. Behavioral activation therapy has been found to be effective as a treatment for depressive disorders in a meta-analysis [6]. The behavioral activation module in this project is based on an earlier internet intervention with mobile phone support [7]. The module focuses on learning to increase the pleasant activity level and to balance the level of necessary activities.

Problem solving therapy (PST). PST has been found to be effective in the treatment of depression [8]. The module has its origins in Self-Examination Therapy [9]. During PST, people learn to get control over their problems by (a) determining what really matters to them (b) investing energy only in those problems that are related to what matters (c) thinking less negatively about the problems that are unrelated and (d) accepting those situations that cannot be changed [9].

Cognitive restructuring (CT). CT in this project builds on existing internet-based interventions for depression from Sweden and The Netherlands, which have been shown effective in the treatment of depression [10]. CT contains information about negative automatic thoughts, how depression is connected to them, ways of discovering negative thoughts, registration of negative thoughts and dealing with negative thoughts.

Exercise. Exercise seems to improve depressive symptoms (11). The exercise module in ICT4D is developed by the project members and entails general information

about physical activity, the relation between physical activity and mood and exercises to increase physical activity level.

Relapse prevention. Research shows that relapse prevention of depression is possible through the use of long-term psychological treatments, and treatments specifically aimed at relapse prevention [12]. In the current project, we developed a relapse prevention module which learns the patient to prepare for future events which can trigger depressive symptoms and to make a plan of action in case depressive symptoms return.

Medication adherence. The medication adherence module aims at providing an adequate and personalized support for the management of patients' drug intakes. The module consists of two sub-modules; the first one aims at identifying barriers to drug adherence. This sub-module is based on the Beliefs about Medicines Questionnaire (BMQ) [13]. Evidence suggests that Measurement-Guided Medication Management (MGMM's) is effective in improving patient's adherence [14]. The second sub-module is an extension of the current implementation of MGMM intervention through ICT-based techniques. In this sub-module, adherence data is collected at the point of need and wirelessly transferred to the adherence sub-system on a regular basis.

Mobile phone

The mobile phone has two functions in the ICT4D project. On the one hand, the patient can use the phone for following treatment modules that are shortened versions of the modules available via the web. On the other hand the phone is used to monitor the patients' progress. In order to give a patient appropriate support one needs to be aware of the therapy progress. The ICT4D system gathers information of this progress via ecological momentary assessment (EMA). EMA is an ecologically valid method of gathering real-time data on context, behavior, and mood in natural environments through the use of signaling devices to minimize recall bias [16].

The patient's wellbeing (mood, quality of sleep and distress) is measured on a daily basis. Patients will receive a pop-up message five times a day to rate their mood at that particular moment. Mood is rated on a scale from 1 to 10. The quality of sleep and level of distress are assessed once a day. The patient receives feedback from the reasoning system about the evolution of his wellbeing status.

In addition to the use of EMA, the activity level of the patient is measured through sensors in the mobile phone. Physical activity monitoring provides feedback in relation to the adherence of the patient to the exercise regime for patients doing exercise treatment. In ICT4D exercise activity is measured in terms of time spent lying, sitting, standing, walking and cycling but is also derived from the time spent in locations indicated by the user as those places where they exercise. A daily activity level is also calculated and used by the reasoning system as a measure for generic user activity levels.

Wearable biomedical sensor devices

Biosignals have been used for studying physical health problems, but limited research has been done to assess the applicability of these signals to the context of mental health problems. In the ICT4D project, a set of wireless miniaturized and non-intrusive

wearable sensors was developed, taking into account considerations about the usability, portability and comfort for the patient, targeting continuous and ecological monitoring. Due to the requirements of the monitored parameters in terms of anatomical location of the signal sources, two form factors were developed, namely a chest strap to be worn at the chest level, and a glove-like device to be used in the non-dominant hand. The glove allows measurement of electrodermal activity (EDA), and blood volume pulse (BVP) at the hand palm, thus not interfering with the regular tasks performed by the patient, while the chest strap allows measurement of respiration, electrocardiography (ECG) and acceleration. Cardiac parameters, such as heart rate, are extracted from the BVP and ECG, while the sympathetic nervous system activity is assessed with the EDA.

Reasoning system

One of the main goals of ICT4D is to provide the patient with a highly personalized and automated treatment based upon the measurements related to how the patient is doing. In order to perform this task, a reasoning engine is part of the system, which incorporates techniques from the domain of Artificial Intelligence, in particular dynamic computational modeling. Essentially, this reasoning engine is composed of four main parts: (1) a component that interprets the sensory information to derive how the patient is doing, and how much the patient is involved in the therapy; (2) a component that derives how the current patient state and involvement is in line with the expectations for this particular therapy; (3) a component that investigates whether another therapeutic module could potentially offer a more successful treatment (by performing simulations) in case the patient is performing worse than expected, and (4) a component to generate feedback to the patient based upon the sensory information and the information derived under (2) and (3). In order to avoid overloading the patient with these messages, a priority-based mechanism has been developed.

The reasoning system provides automated feedback to each patient and the involved primary caregiver. This will give patients a better insight in the progress of their therapy and allows them to increase the effect of their therapy. Feedback will be provided via the smart phone and a personal website.

System architecture

From the software architecture viewpoint, ICT4D is a distributed system, bringing together several modules and system components developed by different partners in a seamless yet loosely coupled fashion. It follows a Service Oriented Architecture (SOA), featuring a cohesive business process for the support of therapeutic modules and ecological momentary assessments alike, as well as an Event-driven Architecture (EdA) implementing individual patient progress across therapies and providing users with asynchronous feedback.

Although the treatments in ICT4D enable the user to have a considerable degree of flexibility, a consolidated database model has been devised. This structure associates inter-related concepts in a stepped therapy and maps them to customized lookup tables, which form the basis for the automated interpretation. It is also expected to contribute to a better user experience, e.g. because makes it possible to present the user with suggestions resulting from previous steps in a therapy.

Two client applications, making use of the same underlying secure web services have been implemented: one for the Web, another one for the Android platform. The ICT4D service architecture can be easily extended with other therapeutic modules or new client applications. Furthermore, if availability requirements determine it, the architecture can be scaled by including new application and/or database servers.

Discussion

This paper describes a highly automated ICT-based system for the treatment of depression. The therapeutic basis of the system is a set of partly new, partly modified internet-based therapies. Through the use of smart phones, ecological momentary assessments and various sensors, an extensive set of patient specific data is collected and analysed automatically by a reasoning engine. The resulting information is used to provide the patient with tailored feedback and advice. The system will be tested during trials with 25 patients with a diagnosis of depression in the Netherlands and Sweden during 2012 and 2013.

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