

Validation Results of a Personalised E-health Framework for the Prevention of the Obesity Disease

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Abstract— Health systems are a valuable tool for empowering individuals to manage their lifestyles and to reduce the incidence of chronic diseases. Home e-health systems can be regarded as a solution to involve users in effectively managing their own healthcare. This paper presents the expert validation of a new framework that enhances the use of e-health services by providing personalized information.

I. INTRODUCTION

Preventing or delaying illness and death from chronic disease is possible. Many of these diseases can be prevented or ameliorated through behaviour changes [1]. At least 80% of all cardiovascular diseases and “type 2” diabetes and over 40% of cancer could be avoided through healthy diet, regular physical activity and avoidance of tobacco use, which are behaviours that can be influenced and modified through education [2].

ICT and its applications are increasingly looked upon as a potential answer to the requirements of a modern society, demanding better healthcare, improvements in medical outcomes and maintenance of a relatively high quality of life, especially with the onset of chronic health conditions coming to the fore as a key issue. Furthermore, implying a view of utilising the technology as a tool for (re) addressing the prevailing state of affairs, ICT tools and applications are also have a potential to support an enhanced access to health information in general and indeed, to the health system in particular [3]. Characteristics such as the tailoring of messages, instantaneous feedback, appeal or engagement are potential advantages that new ICT can provide (adapted from [4]) and that may be of enormous benefit to attain behaviour change.

E-health applications have the capacity to support empowerment of individuals in managing their health concerns and acquiring the necessary resources to achieve their goals. Moreover, they can ensure ubiquitous availability of the tools and communication channels necessary to support empowerment [5]. Even though, although there is much emphasis on the adoption of ICT implementation in the field of healthcare (e-health) [6, 7], there is still a lack of understanding the in-depth rationale on how these applications assist individuals to effectively change lifestyle behaviours.

On the one hand, there is a scarce on studies that relate the use of ICT to change attitude towards healthcare. On the other hand, the studies often focus on the technical aspects of ICT failure, neglecting what has been learned from the behavioural sciences about humans and their interaction with ICT; this relationship may be the answer to understand the added value that ICT bring over traditional channels of healthcare provision. The success of ICT implementation in order to cause a change in individual’s behaviour is often grounded in behavioural science, using theories and models to identify conditions and determinants of successful use [8]. Therefore, finding out why an individual would use an e-health application to change his/her lifestyle would imply paying attention to the behavioural aspects in attitude towards healthcare and in technology readiness.

In order for people to adopt e-health applications within their routine, and therefore increase their awareness of public healthcare topics, an iterative cycle of tailored information and feedback can be repeated to facilitate an individual’s movement through the persuasive process of motivating health behaviour change [9].

This paper presents a new framework based on information tailoring, adapting it to the specific needs and characteristics of the users. Since different stakeholders often have diverse views of e-health applications, a specific evaluation for this kind of system is needed. Provided that none of the existing evaluation methodologies allows validating a complete e-health system, a new methodology has been designed to serve as a guide for the e-health sector stakeholders in the validation process of any kind of related projects.

II. MATERIALS AND METHODS

The designed framework provides personalised information according to a set of variables relevant to the user. Tailoring both the channel and the content of the message has been proven essential for persuading individuals to change their health behaviour [9]. In order to personalise information, a 5-step approach was defined based on the modification of a strategy for the creation of a personalised healthcare communication strategy [10]:

- **Step 1:** Analysing the problem to be addressed and understanding its determinants and defining a new model
- **Step 2:** Developing an assessment tool to measure a person's status on these determinants
- **Step 3:** Creating tailored messages that address individual validation of determinants of the problem
- **Step 4:** Developing algorithms to link responses from the assessment into specific tailored messages to create the final health communication.
- **Step 5:** Final evaluation.

Fig. 1 shows the relationship among these steps.

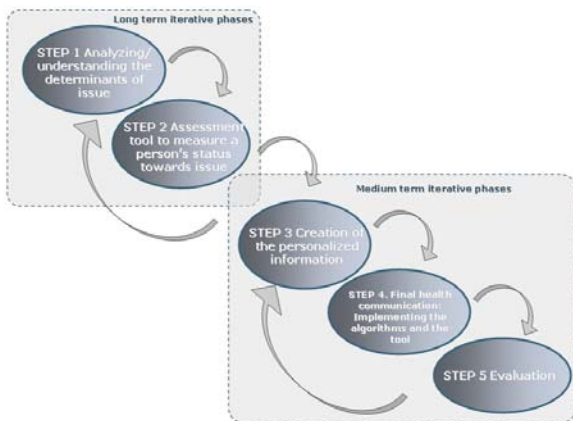


Fig. 1 Personalized healthcare communication strategy

A description of these steps and how they have been applied to the creation and implementation of the framework follows:

STEP 1

Theoretical models are useful in predicting which patients will use e-health and in understanding what factors influence their decisions. Models also can aid in designing and evaluating the ability of specific e-health applications [11]. Currently there is no integrated framework that includes a sufficiently broad set of influencing factors to understand the multidimensionality of the reasons why people use ICT to embrace a healthcare change [8]. There have been previous attempts in understanding whether a single factor may have an effect on their e-health adoption, by partially applying some of the psychological models that explain behaviour change. However, it was noticed that applying only one of the theories (i.e. the “Stages of Change”) [12] was somehow limited as there are a wider variety of factors that influence a user's decision to adopt a change in his/her life in order to perform a healthcare change.

Moreover, without addressing the full range of factors, strategies to change usage behaviour run the risk of being ineffective because they fail to recognise interdependencies between individual and organizational factors [8].

This step focuses on how to promote effective change in health behaviour by means of modern ICT. Therefore, a

detailed study focusing on both healthcare and ICT dimensions was carried out to understand the stage the user is at.

In the first case research developed in psychology and public health that attempts to understand the promotion of health among the populations is complex and there are a number of significant theories and models that underpin the practice of health promotion and individual's attitudes towards the change, these being mainly: the Health Belief Model [13], the Theory of Reasoned Action [14], the Trans-theoretical Model (stages of change) [15] or the Precaution Adoption process Model [16]. These theories explain health behaviour change by focusing on the individual with the principal intention of providing information either to improve knowledge or change behaviour.

In the second case, the performed task focuses on understanding why users would make use of an ICT platform (denominated from now on “e-health” platform) in order to perform a change in their attitude towards health (i.e. use the Internet or a mobile phone to help them quit smoking, to encourage them to follow a diet, etc). However, we only found adoption theories that explained why a user would make use of an ICT platform to carry out a specific ICT-work related task (i.e. adoption of spreadsheets, use of email, word processor, etc) in different environments (companies, hospitals, government agencies, etc) and situations, although not health related attitudes. Studies elaborated show the interest of individuals in using an ICT application but there is no holistic framework to explain the link between these last two (i.e. the use of ICT and changes in health behaviour). The performed work consisted of conceiving and developing an integrative framework that explains the different stages the user is at both in terms of the perception of healthcare and the use of technology to perform any change.

STEP 2

In order to identify the individual's status regarding the variables previously explained, a set of questionnaires has been designed and implemented. These questionnaires allow placing the user at a stage in each of the paths so that we understand what personalised information needs to be provided according the user stage. Other factors, such as personality, age, etc., could provide relevant information but in this work we will focus on the stage at the healthcare and the ICT level.

STEP 3

A set of medical recommendations for each one of the pathologies under study was established in collaboration with health professionals. As a result, personalized messages were developed.

STEP 4

This step focuses on the development of algorithms for the provision of personalised information for the healthy-eating plan. This is achieved by means of a Web-based tool in which messages are provided through different channels according to

different variables. This solution has an additional advantage, since it makes such information available to the user through the Internet. For this purpose, different innovative technologies relative to dynamic Web development have been analysed, such as Java Portlet [17], JSP, Oracle databases, HTML or Macromedia Flash. The selection of these technologies is based on the following requirements: interactivity, personalisation, portability and usability, as well as a potential seamless integration in any kind of system.

The final communication strategy was designed and tested with the doctors.

STEP 5

During this step, an evaluation of the framework is performed. Results show promising and the feedback obtained from the different stakeholders is currently being used to perform a second iteration of the whole communication methodology. Since different stakeholders often have diverse views of e-health applications, a specific evaluation for this kind of systems is needed. Provided that none of the existing evaluation methodologies allows validating a complete e-health system, a new methodology has been designed to serve as a guide for the e-health sector stakeholders in the validation process of any kind of related projects.

III. RESULTS

A. The Model Proposed

The designed model takes into account in parallel both the healthcare stage of the individuals and his technical readiness to perform a change using technologies [18]. The added value of this model is that it allows placing the user at a stage in both dimensions (see Fig. 2).

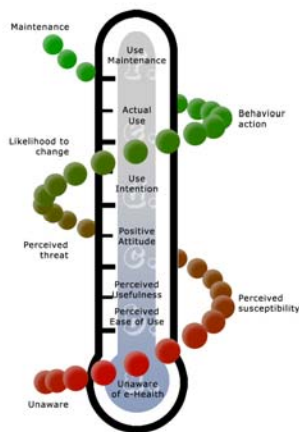


Fig. 2 E-health communication framework

B. The Questionnaires designed

In order to be able to place the user in a stage a questionnaire/survey instrument based on the model presented above has been developed. It takes into account the substantive factors influencing the adoption and readiness of individuals to perform a health behaviour change and in

parallel to do it by means of an e-health application. Based on the stages identified in the model, two different sets of questions have been developed. The questions try to find out the attitude of the user towards two specific variables: one related to the user interest in health (how the user relates to the healthcare stage) and the other related to their motivation and skills to use ICT to promote their well-being (whether the user would be ready to use an e-health application).

On one hand, the health questionnaire assesses whether users have the awareness and the right guidelines to control their health, if they feel susceptible to suffer from that pathology and if currently they are following any healthcare plan. With these objectives in mind, three specific strategies to encourage self-care can be followed: offering correct and personalised information, helping users to employ this information and promoting ICT as a means to support healthcare by easing access to quality information and specific services, helping health problems follow-up and making the relation between patients/users and health professionals closer. On the other hand, the e-health questionnaire identifies whether users have knowledge, motivation or access to use ICT to make a health change.

C. Personalised information

According to the stages presented above, the information offered to the user is selected in line with the main features identified. Then it is presented in the most suitable way so that a change to improve his/her health with the use of ICT can be achieved. Fig. 3 shows the information for a user in Action stage related to the obesity problem.

ACTION	
AGENDA, hints & tips, eaten food/mood register.	
DAYLY	Enter weight in application Physical activity register
	Enter weight
	Feedback with progress: Weight loss, improvements, barriers
	Appointments for face to face visits
WEEKLY	Physical activity registers.
	Other anthropometric tests: bioimpedance (fat %), skinfolds, etc
	Give feedback & identify causes for non compliance with goals.
	Adjustements made to the plan accordingly
	Move to maintenance if behavior maintained 3-6 months

Fig. 3 Specific tailored information offered to a user in Action.

The information displayed has been modelled in collaboration with health professionals, taking to account the structure of a standard medical intervention for a user suffering any of the different pathologies studied.

D. The algorithm developed

The Web platform described has been implemented with the following features:

- To offer personalised information in form, tone and content.
- To be visual, dynamic and interactive.
- To be able to be integrated in an e-learning system.

In this sense, a training activity consists of a multimedia online session presented with a visual and friendly interface (see Fig. 4). The whole process consists of five stages. In each stage, different technologies have been selected to achieve the required functionalities of the full system. These stages are:

Login, Questionnaires, Personalisation, Storage and Presentation.



Fig. 4 Application look & feel

At the Login stage the user's individual information, which have been previously stored in the general profiling process, is recalled from the database records.

At the Questionnaires stage the users' main concern is defined and their motivation status regarding their health is discovered. Steps from Fig.1 have been already used to provide required methodologies to classify the user into each stage, and to suggest appropriate motivational techniques for them.

The Personalisation stage adapts the information to be delivered to the user. The user's profile is modified after the questionnaires are filled in. Thus, the system is personalised according to the user's preferences and completed with the most suitable information.

The Storage stage responds to the need of storing the users' profiles, with all the corresponding security and coherence requirements, to be later used all along the session.

Finally, at the Presentation stage the personalised information and recommendations according to the results of the previous stages are presented to the user.

E. Evaluation of the framework

In order to assess the system in a holistic manner, both validation and evaluation need to be considered. On one hand, validation assesses the concept of the system and the need of such a system. On the other, evaluation analyses the system once it has been implemented. It takes into account aspects such as functionality, appropriateness of scenarios, language, etc. In this sense, both subjective and objective measures have been considered in order to ensure the evaluation process is properly done.

Currently, the framework has been evaluated by means of a set of questionnaires tailored to different audiences: the professionals who have provided their expertise during the conception process, the healthcare professionals (doctors, nutritionists, etc.) and the last one for the citizens. These questionnaires have been developed by applying different evaluation methodologies classified considering the five levels of influence identified for health-related behaviours and conditions. They are: (1) intrapersonal, or individual factors; (2) interpersonal factors; (3) institutional, or organizational factors; (4) community factors; and (5) public policy factors [20].

At the intrapersonal level some of the evaluated indicators have been:

- Behavioural beliefs, intention, attitudes towards behaviour, etc. from the Theory of Planned Behaviour [21].
- Perceived usefulness and perceived ease-of-use from the Technology Acceptance Model [22].
- Performance expectancy, effort expectancy, social influence, facilitating conditions etc. from the Unified Theory of Acceptance and Use of Technology [23].

Related to the interpersonal level, some of the indicators considered are:

- Environment, behavioural capability, self-control, reinforcements, self-efficacy, etc. from the Social Cognitive Theory [24].

For the community level, some of the factors identified have been:

- Innovation, communication channels, innovation's rate of adoption and social system from the Diffusion of Innovations Theory [25].

With the set of questionnaires the framework has been evaluated, finding out how e-health applications could be more effective and successful. Figure 5 illustrates the concept assessment by a group of 20 experts.

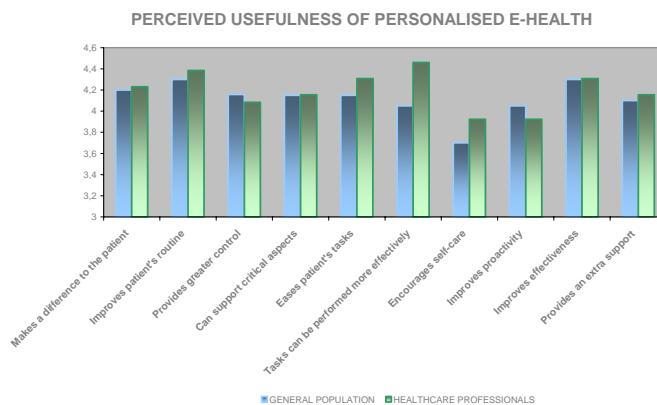


Fig. 5 Results of expert evaluation of the framework concept

Fig.6 shows the satisfaction with the system of the Internet users.

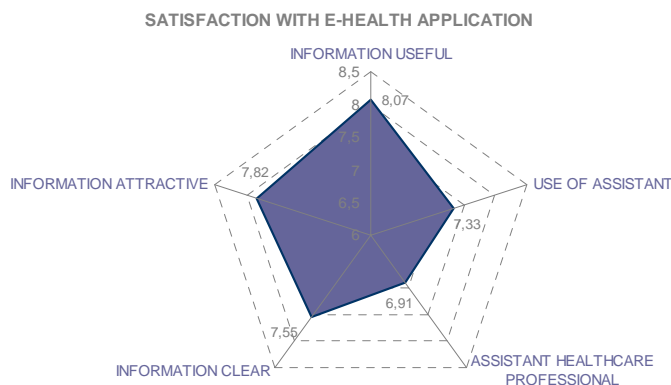


Fig. 6 Internet-users satisfaction with personalized e-health application

Regarding the e-health application itself, the following chart displays the satisfaction with the tool. The usefulness of the information is rated highly (8,07) whereas individuals seem to be less enthusiastic about the use of an e-health assistant, where further work needs to be deployed in order to achieve more natural interaction with the system.

Feedback obtained from the expert evaluation process has reverted into a more usable system.

IV. CONCLUSIONS

Information is critical to health-related decisions and the way this information is selected and processed plays a pivotal role in the decision making of individuals. This framework allows the classification of users according to their attitude towards healthcare, and their readiness to adopt the change by the use of new technologies. It provides a framework for the provision of personalised information according to these and other key variables. Besides, the application of this framework promotes the empowerment of the individuals, as well as guidance, monitoring, through ICT and it will certainly make an impact on health-related behaviour.

One of its main advantages is that this framework may be applied to the conception, design and evaluation of any e-health application. It allows enhancing the user modelling process by taking into account both health behaviour aspects as well as technological, not considered up to now. It may assist both healthcare professionals and individuals to have a deeper understanding about both the provision of healthcare and the delivery channel. However, the inclusion of other dimensions is also necessary in order to be able to effectively reach the individuals.

The health sector is experiencing a huge revolution due to the proliferation of applications that appear as consequence of the convergence of the technological, information and communication sectors, such as the comprised into the group of healthcare services known as e-Health. The main objectives of such services are to empower, benefit and improve the health related activities. The existence of information easily reachable by means of tools like the one presented in this paper enables a more fluent professional/patient relationship, since both parts have access to the same resources to be informed about diagnostic, therapy and prognosis. These tools will never substitute the role of the doctor in diagnostics and therapy, but help patients in raising awareness of their conditions and encouraging them to assume healthier lifestyles. Health professionals emphasize the importance of motivation in improving the lifestyle of the individual. This tool tries to serve as a guide to the user through the different stages of motivation described in the e-health framework presented until the desired healthy behaviour is assumed.

Overall, this framework is likely to provide deeper insights into the process of improving e-health, so it can meet ongoing individuals' needs and become an increasingly valued part of health care services.

A more in-depth evaluation of the tool needs to be designed and carried out. A larger sample of users and long-term use of the tool needs to be assessed in order to understand how

personalised e-health applications need to be designed to better tailor to the individuals' needs.

ACKNOWLEDGMENT

We would like to thank the PIPS Project (partially funded by EC, IST 507019), in which this framework has been tested.

REFERENCES

- [1] World Health Organization, 2005. Facing the Facts: solving the chronic disease problem.
- [2] U. S Department of Health and Human Services. The Health Benefits of Smoking Cessation: centers for Disease Control, Centers for chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 1990. Report N° (CDC) 90-8416.
- [3] The Euser Project. eUser – Workpackage 1: Conceptual and Analytical Framework. D1.1: eUSER Conceptual and Analytical Framework (Part A and Part C). European Commission, 6th Framework Programme. Contract number: IST-2002-507180.
- [4] Glanz, K , Rimer, B and Lewis FM, 2002. Health Behaviour and Health Education: Theory, Research and Practice. 3rd Edition. John Wiley & Sons. ISBN 0-7879-5715-1.
- [5] Brennan P. F., and Safran, C. (2005). Empowered Consumers. In consumer Health informatics. Editors. Lewis D., Eysenbach, G., Kukafka, R. et al. Springer, 2005. ISBN 0-387-23991-x.
- [6] Lorenzi, NM., Riley RT., Southon G and Dixon, BG., 1977. Antecedents of the people and organizational aspects of medical informatics: review of the literature. J. Am. Med. Inform. Assoc. 4, pp. 79-93.
- [7] Curtis B., Krasner, H. and Iscoe N. 1988. A field study of the software design process for large systems. Commun. ACM 31, pp. 1268-1286.
- [8] Kukafka, R., Johnson S. B., Linfante, A., and Allegrante, J.P., 2003. Grounding a new information technology implementation framework in behavioral science: a systematic analysis of the literature on IT use, Journal of Biomedical Informatics, Volume 36, Issue 3, June 2003, Pages 218-227.
- [9] Kukafka, R., (2005): Tailored Health Communication. In Consumer Health Informatics. Informing Consumers and Improving Health Care. Series: Health Informatics. Lewis, D.; Eysenbach, G.; Kukafka, R.; Stavri, P.Z.; Jimison, H. (Eds.).
- [10] Kreuter M., Farrell D, Olevich L, et al. (2000). Tailoring Health Messages: Customising Communication with Computer Technology. Mahwah, NJ: Lawrence Erlbaum, 2000.
- [11] Vance Wilson, E., Lankton, N.K., (2004). Modeling Patients' Acceptance of Provider-delivered E-health. Journal of the American Medical Informatics Association Volume 11 Number 4 Jul / Aug 2004.
- [12] Del Hoyo-Barbolla, E., Fernandez, N., Ramirez, C. M. Tortajada, D., Ngo de la Cruz, J., Arredondo, M. T., 2005. Personalised training tool using Virtual Reality. Proceedings of the 1st workshop on personalisation for e-health. 10th International Conference on User Modelling. Edimburgh, UK.
- [13] Fishbein M, Ajzen I, 1975. Beliefs, Attitudes, Intention, and Behavior: an Introduction to Theory and Research. Reading, MA: Addison-Wesley.
- [14] Fishbein M. A theory of reasoned action: some applications and implications. In: Page MM, ed. 1979 Nebraska Symposium on Motivation. Lincoln, NE: University of Nebraska Press, 1980.
- [15] Prochaska JO, DiClemente CC. Stages and processes of self-change of smoking: Toward an integrative model of change. J Consult Clin Psychol 1983;51:390-5.
- [16] Weinstein, N. D., and Sandman, P. M., 1992. A model of the Precaution Adoption Process: Evidence from home Radon testing. Health psychology, 1992, 11, 170-180.
- [17] D. DeWolf, "Introduction to the Java Portlet Specification", Developer.com, September 8, 2005.
- [18] Hoyo Barbolla, Eva del (Abril 2007) E-health reference framework for personalised information provision to promote sound lifestyles. Tecnología Fotónica / E.T.S.I. Telecomunicación (UPM). <http://oa.upm.es/332/>
- [19] Del Hoyo-Barbolla, E., Kukafka, R., Arredondo, M.T., Ortega-Portillo, M., (2006): A new perspective in the promotion of e-health. In

- Ubiquity: Technologies for Better Health in Aging Societies. A. Hasman et al. (Eds.). IOS Press, Pgs. 404-412.
- [20] McLeroy, K. R., Bibeau, D., Steckler, A. and Glanz, K. (1988) An ecological perspective on health promotion programs. *Health Education Quarterly*, 15, 351–377.
- [21] Ajzen, I. (1991). "The theory of planned behavior, *Organizational Behavior and Human Decision Processes*". N° 50, pag. 179-211.
- [22] Davis, F. 1989. "Perceived usefulness, perceived ease of use, and user acceptance of information technology". *MIS Quarterly*, 13(3), 319-340.
- [23] Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F.D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425-478.
- [24] Bandura, A. "Social foundations of thought and action: A social cognitive theory". Prentice-Hall, Englewood Cliffs, NJ, 1986.
- [25] Diffusion of innovation. <http://www.stanford.edu/class/symsys205/Diffusion%20of%20Innovations.htm>