31st Annual International Conference of the IEEE EMBS
Minneapolis, Minnesota, USA, September 2-6, 2009

Personal Health Promotion through Personalized Health Technologies – Nuadu Experience

I. Korhonen, E. Mattila, A. Ahtinen, J. Salminen, L. Hopsu, R. Lappalainen, T. Leino

Abstract—**Poor lifestyles – overweight, unhealthy diet, physical inactivity, sleep deprivation, and stress – are significant risk factors to chronic illnesses, which cause majority of the health care costs. Hence, behavioral change towards healthy lifestyles is one of the keys to health care cost containment. Personal health systems (PHS) offer tools to support behavioral change. As health risks, personal needs and preferences vary from an individual to another, personalization of the PHS is needed. In Nuadu project we have developed a PHS integrating several different personal health technologies. This system was studied in a large (N=354) randomized controlled trial where employees with several health risks participated in a health promotion program. The study will finish in June 2009. User feedback and technology usage logs reveal that especially simple mobile technologies were actively used during the program. However, usage models varied between individuals and time, and there was a significant number of both active users and non-users. The results emphasize that "one size" does not fit all, and instead of individual "killer applications", PHS with different personalizable and interoperable options should be developed. In addition, screening and profiling methods should be developed to identify those users who would best accept and benefit from technology-supported health promotion. Successful technologies combine high usability and conceptual simplicity to clear and perceivable added value for the end users.**

I. Introduction

Poor lifestyles – overweight, unhealthy diet, physical inactivity, sleep deprivation, and stress – together with ageing are contributing to increase in the prevalence of chronic diseases. Chronic conditions, such as cardiovascular diseases, diabetes, asthma, cognitive disorders, etc. are causing above 60% of the disease burden in OECD countries. Adoption of healthier lifestyles would significantly prevent incidence of chronic illnesses, e.g. in the case of type II diabetes up to 90% of new cases could be prevented. In addition, lifestyle modifications play a central role in the effective management of the chronic conditions. Relevant lifestyle factors, which include diet, daily activity, sleep, and stress, play a central part in our everyday life, and they are not only regulated through conscious (health) decisions but through our unconscious acts. Therefore, health promotion through lifestyle modification is only partially a healthcare issue – it is rather a very personal issue where factors such as personal preferences, personal values, and more generally social and psychological factors play a significant role. Attempts towards health promotion and disease prevention should therefore apply a holistic and personal approach which acknowledges factors beyond traditional health care domain, and are not only information- but motivation-centred.

Modern psychological theories on motivation, behavior, and behavioral change provide framework which can be utilized in health promotion and chronic disease management [1]-[3]. *Behavioral economics* [4] introduce further aspects on how system designers can apply these theories, abandon concept of rationalism as a main driver for human decision making and behavior, and design *choice architectures* which nudge users towards healthier selections and lifestyles.

In Nuadu project, we have designed a Personal Health System (PHS), the Nuadu concept, which integrates several personal health technologies for health promotion [5],[6]. The Nuadu concept, or "toolbox", was further integrated into a health promotion programme, which was based on modern psychological theories (cognitive behavioral theory, acceptance and commitment therapy, and transtheoretical model of change). The programme combined workplace group interventions with personalized goal setting and action plan, which were supported by personal technologies. The provision of several parallel technology options allowed personalization of technologies according to user needs and preferences. The Nuadu concept has been studied in a randomized controlled trial with 354 participants of whom 118 belonged to the technology group. The follow up time is 1 year. The follow-up is to finish in June 2009. In this paper, we summarize some findings related to user feedback and technology usage patterns in the technology group.

II. Nuadu Study

A. Nuadu Technology Concept

The Nuadu technology concept has been described in detail elsewhere [5][6]. In short, the concept integrated four

Manuscript received April 23, 2009. This work was supported by the Finnish Funding Agency for Technology and Innovation (Tekes).

I. Korhonen and E. Mattila are with VTT Technical Research Centre of Finland, Tampere, Finland (phone: +358-20-722-3352, fax: +358-20-722-3499, e-mail: ilkka.korhonen@vtt.fi, elina.m.mattila@vtt.fi).

A. Ahtinen and Jukka Salminen are with Nokia Research Center, Finland, (e-mail: aino.ahtinen@nokia.com, jukka.h.salminen@nokia.com)

R. Lappalainen is with University of Jyväskylä, Department of Psychology, Jyväskylä, Finland (email raimo.lappalainen@psyka.jyu.fi)

J. Laitinen, L. Hopsu and T. Leino are with the Finnish Institute of Occupational Health, Helsinki, Finland (e-mail: leila.hopsu@ttl.fi; timo.leino@ttl.fi).

different types of personal health technologies (Fig 1):

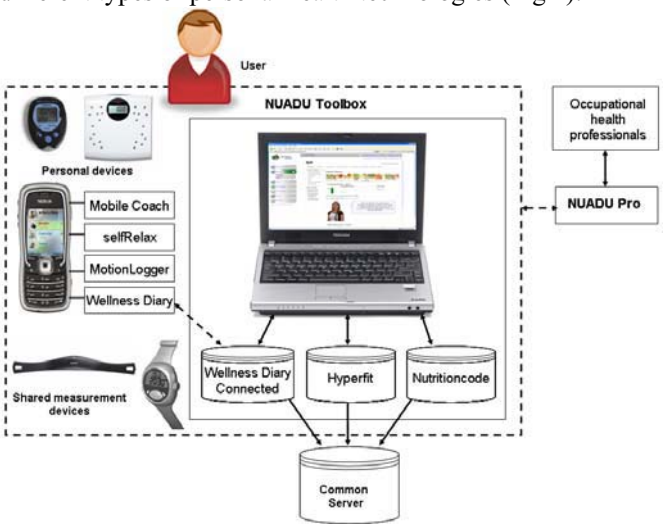

Fig. 1. Nuadu technology concept

1) Personal devices are monitoring devices designed for daily personal use. These devices monitor health or behavior related parameters, and are designed for daily personal long-term use. This usage model requires very high level of usability, robustness and affordability. In Nuadu, step counter and weight scale were used as personal devices.

2) Mobile tools are health applications running on a mobile platform and designed for personal contextual daily long-term use. These applications may acquire information from other sources (e.g. personal devices or other sensors, or electronic personal health records) but their main role is to provide tools supporting daily health management e.g. weight or stress management or exercise planning. In Nuadu, these tools included Wellness Diary (a mobile diary for monitoring and getting feedback on several wellness parameters [7]), MobileCoach (an application for personal exercise program planning and monitoring [8]), and SelfRelax (an application for guided relaxation based on audio feedback [9]).

3) Web-tools are web-based applications running on the Internet and designed for personal long-term use, either on daily or intermittent basis. As compared to mobile tools, web and PC interface allows richer content and interaction but lack continuous contextual access to it. In Nuadu, these tools included Wellness Diary Connected (a web counterpart for Wellness Diary [10]), Hyperfit (rich personal food diary [11]), and NutritionCode (a service for automatically analyzing the nutritional content of groceries [12]).

4) Other monitoring devices are devices which provide accurate data related to health and behaviours, but are too inconvenient, impractical or costly to be used continuously. Instead, these technologies may be used intermittently when needed, e.g. for screening, assessment or progress evaluation purposes. As technology progresses, some of these technologies may be moved to personal devices class as well. In Nuadu, these devices included a beat-to-beat heart rate monitoring memory belt (Smartbelt by Suunto, Vantaa, Finland) and a telemetric actigraph (Vivago Oy, Helsinki, Finland). However, the latter was not used in the study due to a delay in availability. In addition, specific analysis software and algorithms were included for processing and analysing the acquired data and providing feedback.

Together, these technologies made up the Nuadu concept in this study but the concept supports adding new technologies to the system. During the study, different technologies were partially interoperable [6] although the ultimate goal is complete data level interoperability. The tools were offered to the users as options, i.e. the users were given access to all the tools but they were free to choose to use only those technologies which they perceived as useful and valuable; they were also free to change their choices at any time. In other words, users could personalize their PHS according to their own needs and preferences.

B. Nuadu intervention programme

Nuadu intervention programme for workplace health promotion was designed by a multi-disciplinary resource group from the Finnish Institute of Occupational Health and University of Jyväskylä on the basis of modern psychological theories and best intervention practices. The health promotion programme targeted to address several different health risks in parallel, reflecting to the fact that different health risks tend to cluster and hence most participants would have different mixture of several risks. The programme applies cognitive behavioural therapy, acceptance and commitment therapy and problem solving in a generic form to address most relevant health behaviours and therefore allows participants to focus on those problems they find relevant for themselves and choose to work on. The programme was delivered in a group intervention format, consisting of 5 consecutive group intervention meetings (groups 8-10 participants, 1.5h per session) with varying focus. Meetings consisted of information delivery, exercises, and introductions to technologies and health management methods. The participants were free to choose which health problems they started working on, to make their personalized plans, and to set their personal goals. They were guided for the use of Nuadu technologies to support their health management.

C. Nuadu trial

Nuadu technology concept has been evaluated in a 1-year randomized controlled trial with City of Espoo employees in Finland (Fig 2). First, the participants were screened with a health questionnaire assessing their health risks and motivation to change their lifestyles. Those with at least two health risks, motivation to change, and lacking physical illnesses were eligible. 354 participants were chosen and randomly divided into three groups: Nuadu technology intervention (n=118), traditional intervention (n=118), and control group. (n=116) The active phase of the intervention programme (meetings) lasted approximately three months,

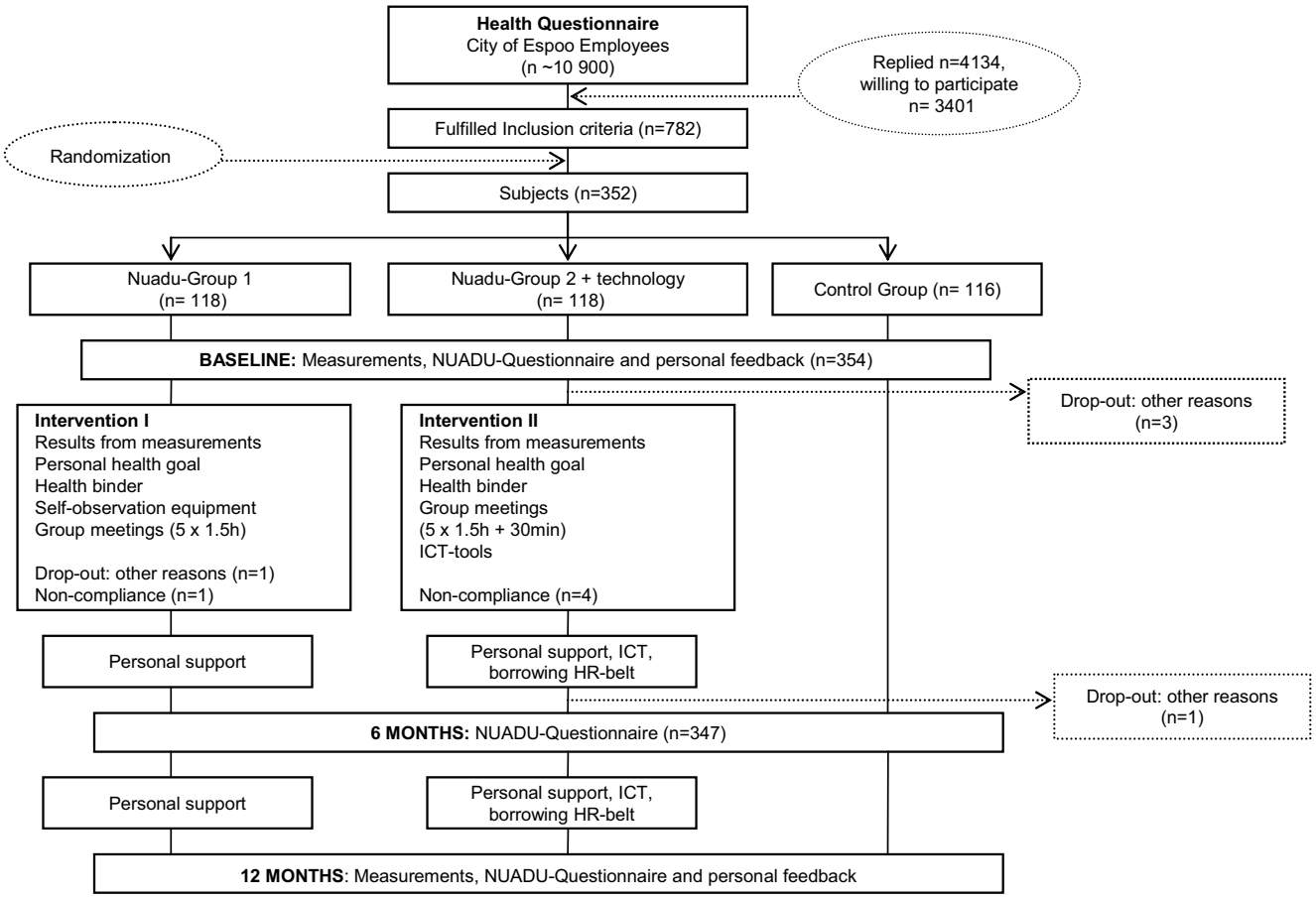

Fig 2. Nuadu trial design and intervention process. Numbers indicate participants and drop-outs in each phase. Health Questionnaire was used to screen participants who fill the inclusion criteria.

with total duration of the follow up of 12 months. In addition to health intervention programme, the participants' health and health behaviors were examined in detail at the beginning and end of the study, and they responded to usability and technology related questionnaires at 0, 1, 3, 6 and 12 months [13]. The study started in February 2008 and will finish in June 2009. The outcome measures include changes in health status, health behaviors, and health attitudes.

III. RESULTS

In the following, we report some results from the technology group. The mean age of the group was 45y (range 31-56), with 70% female participants. 8 subjects had vocational education or had been trained at work, 66 had vocational or polytechnic education, and 45 had a Master's level or higher university degree. Their prior use of technology was comparable to average technology usage patterns in Finland [13]. Participants used mobile phone on daily basis for calls and text messages, and most of them (90%) carried the mobile phone with them while exercising [13]. Many of them owned step counters (40%) or heart rate meters (33%) but few (11% and 3%, respectively) used them regularly [13]. They also believed mobile and wearable technologies to be more motivating for them to reach their health goals [13].

There have been remarkably few drop-outs in the study (Fig 2). This reflects both successful screening procedure to choose those participants who were truly motivated to work towards healthier lifestyles, and successful design and implementation of the intervention programme.

At the time being, 93 users in the technology group have completed the study. Of them, 56 (60%) have been using some mobile technology actively during the study. In agreement with [13], Wellness Diary has been the most popular application (44% or 41 active users), while SelfRelax has been used actively by 27 (29%), and MobileCoach by 10 (11%) users throughout the study. The most popular wellness parameters to follow were weight, steps and exercise. However, most of the parameters of the Wellness Diary had their active users, and hence could be considered relevant. For example, people suffering from stress perceived sleep as more relevant parameter to follow up than stress itself [13]. The web-tools were used less frequently than the mobile tools or personal devices.

IV. Discussion

We have developed a PHS which integrates several personal health technologies and evaluated it in connection with a novel workplace health promotion intervention programme, which was specifically designed to utilize technologies for personal and personalized health promotion. The study is still on-going and will finish in June 2009. The most interesting research question "Do PHS have impact on health or health behavior of the participants" in this setting may be answered only after we have information about true changes in health and health behavior status of the participants i.e. when the study is finished. Currently, we have reported some notes on success of the trial so far as well as some technology usage patterns.

Health risks – overweight, inactivity, poor diet, stress, sleep problems, smoking, alcohol usage – tend to cluster but in an individual manner i.e. individuals have typically several but mutually different mix of health risks. Therefore, attempts should be made to develop methods which support management of several different risks in a coordinated fashion. Our combination of group intervention programme targeting several possible health risks simultaneously or optionally, and personalised problem addressing, goal and action plan setting, makes the approach potentially cost-efficient as it allows delivery of the intervention for various different settings and to participants with varying needs and interests. Therefore, it eliminates the need to provide separate programmes for each different health risk. In our study, the exceptionally low number of drop-outs suggests that the intervention program focusing simultaneously on several health risks has been successful at least in keeping the participants motivated to stay in the programme. If the eventual health outcomes evidence health benefits from the programme, this approach is highly encouraged. PHS are a significant enabling technology to support this approach as they offer tools for personalisation and citizen empowerment despite the format of group intervention as programme delivery method. Our approach also builds on recognition that for optimal outcomes PHS should be accompanied with specifically designed service models which utilise them and motivates their use.

There was a significant sub-group (>60%) of participants in the technology group who kept actively using some of their preferred technologies throughout the study. The most preferred technologies were those which were conceptually the most simple and most usable, i.e. simple mobile wellness diary, and pedometer [13]. This suggests that the successful PHS should be designed to opt for simplicity, conceptual clarity, very high usability and unobtrusiveness, and good fit to daily life habits. However, also more complex technologies had their fans and active users. This demonstrates that our approach to provide users with a variety of options and to allow them to choose their own preferences, is important. The search for ultimate killer application for wellness technologies may hence not be successful but rather we should design for flexibility and interoperability of different technologies to support parallel PHS options for different users even within same programmes. Furthermore, we should develop methods for profiling and screening the users so that we can identify already early who are the users who benefit from PHS the most and to whom we should offer more traditional approaches, such as technology based or traditional intervention programmes [10].

Acknowledgment

This study is a part of ITEA2 Nuadu project, coordinated by Philips. The partners in the Finnish consortium are: Afetco; Coronaria Impact; Finnish Institute of Occupational Health; Firstbeat Technologies; Hema Institute of Healthcare Engineering, Management and Architecture; Vivago Oy; Nokia Research Center; Tuulia International; and VTT Technical Research Centre of Finland.

References

[1] J. O. Prochaska and J. C. Norcross, "Stages of change," *Psychother.*, vol. 38, pp. 443-448, 2001.

[2] J. P. Elder, G. X. Ayala, and S. Harris, "Theories and intervention approaches to health-behavior change in primary care," *Am. J. Prev. Med.*, vol. 17, pp. 275-284, 1999.

[3] Z. Cooper, C. G. Fairburn, and D. M. Hawker, *Cognitive Behavioral Treatment of Obesity*. New York: Guilford Press, 2003.

[4] R. H. Thaler, and C. S. Sundstein, Nudge. New Haven, CT: Yale University Press, 2008.

[5] E. Mattila, J. Koskelo, R. Lappalainen, J. Salminen, P. Nyman, J. Lähteenmäki, T. Leino, and I. Korhonen, "A concept for ICT assisted health promotion in the occupational healthcare," in *Proc. 29th Ann. Int. Conf. IEEE-EMBS 2007*, EMBC 2007, Lyon, France, Aug. 23-26, pp. 1786-1789, 2007.

[6] E Mattila, I Korhonen I, R Lappalainen, A Ahtinen, L Hopsu, T Leino. NUADU Concept for Personal Management of Lifestyle Related Health Risks. In: *Proc. 30th Ann. Int. Conf. IEEE-EMBS 2008,* EMBC 2008, Vancouver, Canada, August 20 – 24, pp. 5846-5850, 2008.

[7] E Mattila, J Pärkkä, M Hermersdorf, J Kaasinen, J Vainio, K Samposalo, J Merilahti, J Kolari, M Kulju, R Lappalainen, I Korhonen. Mobile diary for wellness management – results on usage and usability in two user studies. IEEE T-ITB, 12(4):501-512, 2008.

[8] Mobile Coach website, available online: http://www.firstbeattechnologies.com/index.php?page=145

[9] SelfRelax website, available online: http://www.relaxline.com/index.htm

[10] A Särelä, J Salminen, E Koskinen, O Kirkeby, I Korhonen, D Walters. A home-based care model for outpatient cardiac rehabilitation based on mobile technologies. In: Proceedings of the 3rd International Conference on Pervasive Computing Technologies for Healthcare, London, UK, April 1-3, 2009.

[11] P. Järvinen (Ed.), "Hybrid media in personal management of nutrition and exercise," VTT Publications, Espoo, Finland, 2007. Available online: http://www.vtt.fi/inf/pdf/publications/2007/P656.pdf

[12] Nutritioncode website. Available online: http://www.nutritioncode.com/nc/nc_login.asp.

[13] A Ahtinen, E Mattila, A Väätänen, L Hynninen, J Salminen, E Koskinen, K Laine. User Experiences of Mobile Wellness Applications in Health Promotion. . In: Proceedings of the 3rd International Conference on Pervasive Computing Technologies for Healthcare, London, UK, April 1-3, 2009.