journal homepage: www.intl.elsevierhealth.com/journals/cmpb

Health-enabling technologies for the elderly – An overview of services based on a literature review

Wolfram Ludwig, Klaus-Hendrik Wolf, Christopher Duwenkamp, Nathalie Gusew, Nils Hellrung, Michael Marschollek, Markus Wagner, Reinhold Haux*

Peter L. Reichertz Institute for Medical Informatics, University of Braunschweig – Institute of Technology and Hannover Medical School, Muehlenpfordtstr. 23, 38106 Braunschweig, Germany

ARTICLE INFO

Article history:
Received 3 November 2011
Accepted 3 November 2011

Keywords:
Health-enabling technologies
Telecare
eHealth
Telehealth
Ambient assisted living
aal
Medical informatics

ABSTRACT

Background: Services for the elderly based on health-enabling technologies promise to contribute significantly to the efficiency and effectiveness of future health care. Due to this promise, over the last years the scientific community has designed a complex variety of these valuable innovations. A systematic overview of the developed services would help to better understand their opportunities and limitations.
Objective: To obtain a systematic overview of services for the elderly based on health-enabling technologies and to identify archetypical service categories.
Methods: We conducted a literature review using *PubMed* and retrieved 1447 publications. We stepwise reduced this list to 27 key publications that describe typical service archetypes.
Results: We present six archetypical service categories, namely *handling adverse conditions*, *assessing state of health*, *consultation and education*, *motivation and feedback*, *service ordering* and *social inclusion* and describe their implementation in current research projects.

1. Introduction

Health-enabling technologies for the elderly have become a major research interest in medical informatics. This is reflected by the constantly growing number of publications in scientific journals concerning this topic (e.g. [1–7]). In its recommendations on education in biomedical and health informatics, the International Medical Informatics Association has even explicitly mentioned pervasive, sensor-based and ambient technologies in health care as required learning outcomes for medical informatics specialists ([8], p. 133, item 3, 13). The increased research interest in these innovative technologies is evoked by their likely contribution to the efficiency and effectiveness of future health care. However, despite this high potential, services based on these technologies hardly leave the state of research projects. This is due to several challenges that have to be met before integrating such services into the practice of health care provision:

(I) Fundamental for the provision of services based on health-enabling technologies are reliable physical and logical tools. Only dependable technologies permit dependable services in health care processes and the everyday life of elderly people. Thus, before they can be adopted, the health-enabling technologies have to leave the state of error-prone prototypes and reach the reliability of a medical product. In the last years, a lot of research has been done to prepare health-enabling technologies for their practical use (c.f. [9,10]).
(II) Based on reliable technologies, reliable services can be designed. To be instrumental these services have to meet the requirements of real life use cases. Thus, for

* *Corresponding author*. Tel.: +49 0531 391 2128; fax: +49 0531 391 9502.
E-mail address: wolfram.ludwig@plri.de (W. Ludwig).
0169-2607/$ – see front matter © 2011 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.cmpb.2011.11.001

their design a lot of interdisciplinary work between all stakeholders and the service engineers has to be done. This makes the development of telehealth services a very complex and challenging task, which is beyond pure technical development. Some scientific publications presented below have conceived full services for elderly people. Nevertheless, to the authors' knowledge, no review exists that focuses on the service layer of health-enabling technologies for elderly people.

(III) Even if the conceived services meet the requirements of all stakeholders optimally, they often make new types of health information accessible or provide well-known and often used information in a different way. In both cases, an adaption of existing health care processes, health information systems and information management is indispensable. Essén and Conrick partly elucidate these challenges in their study [11]. They explore the implementation of an in-home activity monitoring system in a Swedish community care organization and describe the resulting organizational problems.

Due to these challenging tasks, services for elderly people based on health-enabling technologies are rarely implemented as real life applications. A systematic overview on these services could contribute to the body of knowledge and help on the way to a better understanding of their opportunities and limitations. As stated before, in our opinion the integration of health-enabling technologies often leads to an adaption of existing health care processes, health information systems and health information management. An overview of currently discussed services based on these technologies would allow a better preparation for this integration and support a systematic engineering of these services.

2. Objectives

The objectives of our study are:

(1) To obtain a systematic overview of services based on health-enabling technologies for the elderly.
(2) To identify archetypical service categories.

3. Background

To our knowledge, no other review focusing on services based on health-enabling technologies for elderly exists. However, there is some related work, which as well might be of interest for the reader.

Technological aspects of telemonitoring for elderly patients are for example presented by Karunanithi [9]. The author analyzed publications on telehealth monitoring and assessed the monitoring purpose, the status of wearable monitoring technologies, their integration into existing systems as well as the anticipated benefit. As a result of his review Karunanithi states that wearable monitoring technologies and information communication technologies can meet care demands. However, at the same time the authors state, that frameworks, guidelines and standards for their design and application are still needed ([9], p. 275).

Martínez et al. as well reviewed literature on home monitoring [10]. In their review, they assessed feasibility and impact of these applications for patients with heart failure. The authors state that only few data on these aspects is published. However, they report evidence on apparently positive economic and care effects of home monitoring applications (c.f. [10], p. 239).

Brignell et al. present a review on telemedicine applications in geriatric medicine [12]. The authors conducted a thorough analysis of publications on telemedicine from 1990 to April 2005. Regretfully they give no concrete definition of their inclusion criteria, so one cannot say for sure how the authors define 'telemedicine'. In their publication, they reference selected papers, which they consider most important and relevant ([12], p. 370). From their analysis, they draw the conclusion, that telemedicine can increase the effectiveness and efficiency in geriatric medicine ([12], p. 373). They state that improved efficacy and patient satisfaction is especially reported for chronic disease management, but claim that further research on the evaluation of telemedicine in the care of the elderly people is required ([12], p. 372).

To a certain extent, Barlow et al. follow this request, presenting a review on the benefits of home telecare for elderly people [13]. In this review, the authors have included randomized controlled trials and large observational studies that examine the effects of using telecommunication technologies for monitoring vital signs and security issues at home and for information provision. The authors report on an improvement of home care for people with long-term conditions and frail elderly caused by telecare ([13], p. 178). Nevertheless, they as well state that the strength of this evidence depends on the type of telecare application ([13], p. 178) and that only half of the included studies suggest positive clinical benefits while the other half reports no effect ([13], p. 178). However, the authors have found indications that a proactive support from practitioners by telephone can improve the clinical outcome ([13], p. 178).

Bowles et al. conducted a related review, summarizing published empirical evidence about the effects of telehomecare on older adult patients with chronic diseases over the years 1995–2005 [14]. They analyzed 19 studies, assessing the effects on older adult patients, on chronic illness, on telehomecare providers and costs. The authors state that the analyzed publications suggest telehomecare to be feasible and acceptable to patients and caregivers and that this technology can improve the outcomes amongst patients with chronic diseases ([14], p. 13). However, they suggest more rigorous studies of telehomecare technology with larger populations as an area of future research to assess more reliable outcome data ([14], p. 13).

4. Description of method

To achieve the objectives introduced in Section 2, we conducted a literature review. In this review, we targeted publications on services for elderly people based on health-enabling technologies. We defined these services as services based on informatics tools that systematically process data,