inSERT – An NFC-based Self Reporting Questionnaire for Patients with impaired fine motor skills

Andreas Prinz, Philipp Menschner, Matthias Altmann, Jan Marco Leimeister
Chair for Information Systems
Kassel University
{Prinz, Menschner, Altmann, Leimeister}@uni-kassel.de

***Abstract*— Self-reporting patient data are valuable feedback for medical treatment and care process, as well as for clinical trial studies and support of medical treatment. However, traditional paper-based medical patient longitudinal surveys or questionnaires for health and well-being status information are time- and cost-consuming, and may suffer from low patient compliance. Consequently, an NFC-based electronic data capture prototype called inSERT has been designed that allows quick and easy self-reporting for patients. inSERT allows patient monitoring enabling, electronic acquisition of well-being data right from the patient's home and real time representation of patient data, enabling direct medical intervention by physicians. The functional requirements for the inSERT system were determined through an extensive, user-centric elicitation process. We chose Near Field Communication (NFC) as a technology, for which the interaction paradigm is quick to learn and is intuitive, without prior knowledge being necessary; it is almost as simple as to fill out a paper-based questionnaire.**

Particularly for the target group (elderly people and people with impaired fine motor skills) - those who are not familiar with the use of mobile phones or computers - it makes NFC a very promising field compared to the control with touch based displays or computer mouse. The prototype is currently evaluated in a field test. The technical feasibility, implementation details, limitations and future research approaches are discussed in this paper.

I. Introduction

Patients suffering from chronic diseases often have to cope with limitations and a reduced quality of life. This is particularly applicable for patients with limited or impaired fine motor skills, which can occur from chronic diseases such as motor neuron disease, dementia, Parkinson's disease or multiple sclerosis. For most diseases of this kind, a cure remains elusive, despite availability of certain medications to treat symptoms. The protracted course of the diseases has a major impact on the quality of life of patients and their families [1, 2].

Throughout the past decade, mobile devices have achieved a high level of public acceptance, and are also increasingly considered to be integrated in health care [3]. Developing and testing mobile applications is an emerging area of research in the field of Human-Computer Interaction [4] [5]. In this paper we describe the development and implementation of a mobile NFC-based electronic data capture (EDC) system for patient self-reporting questionnaires.

The insufficient information logistics amongst physicians, patients and nursing staff concerning the well-being of patients could be improved by using mobile networks and information systems. Therefore, the objective of our work is to provide a simple, effective and efficient self-reporting system of the current well-being status. Furthermore, the potential solution would allow patients a cost-efficient and easy-to-handle self-reporting system of their current condition. Telecommunication networks allow a flexible, location-independent monitoring of the status of patients even in real time. Additionally, costs can be reduced as patients take over data acquisition tasks.

In order to guarantee best treatment procedures, physicians need to be up-to-date with information about their patients' actual state and well-being. Yet, it is well recognized that capturing, archiving, analyzing and interpreting health status information involve logistic challenges [6]. For patients living at home, this implies an even greater challenge, as contemporaneous information that can be efficiently and effectively used for therapeutic decision-making is not available.

The effectiveness of medical processes can be improved by EDC systems. EDC is more cost efficient, and can additionally improve standards of medical care as well as quality of life. This is made possible by integration of patients into the treatment processes.

Well-being status information has traditionally been gathered using paper-based questionnaires. We have identified a scenario that can profit from applying EDC techniques, both from an economic perspective as well as from the impact on health status and quality of life. These are rating scales and disease progress questionnaires.

In order to reach these objectives, we elicit requirements for an EDC system, develop a prototype, collect data from user groups, examine the evidence and draw conclusions for an EDC system for patients with impaired fine motor skills.

The next sections provides an overview of related research on NFC technology and EDC methods used in patient care,

978-0-7695-4327-7/11 $26.00 © 2011 IEEE
DOI 10.1109/NFC.2011.10

clinical trials, and Ambient Assisted Living (AAL) scenarios. This is followed by a description of the inSERT (Self-Reporting questionnaire) prototype system. We present its functionalities, the application environment and its technical implementation. Further, the benefits of the proposed system for patient self-reporting and EDC in medical treatment are presented. We close with a discussion of the contributions from this research, the implications and the derived recommendations for future research on contactless electronic capture of self-reported patient data.

II. Theoretical Background and Related Work

A. Patient rating scales

Over the last decades, there has been steady progress in the development of measurement techniques for all kinds of diseases. A wide variety of rating scales is used to determine the state of patients, ranging from impairment scales to health-related quality of life instruments (e.g., [1, 7, 8]). Studies have shown their importance in measuring the impact of different diseases and their treatment on patients [9]. The results of the rating scales and questionnaires are then used to adapt and optimize therapeutic options. However, traditional paper-based medical patient surveys or questionnaires for health status information are time- and cost-consuming, and can suffer from contaminating effects, such as time-delay or inaccuracy due to oblivion, which can lead to unsuited or non-up-to-date treatment. Several studies have evaluated the effectiveness of patient self-rating for different kinds of diseases [10]. They show that the validity and reliability are of a sufficient level in order to serve as a basis for treatment decision-making. Follow-up costs of inadequate treatment are hard to measure, and the negative impact on patients' quality of life is manifest.

Health status information has traditionally been captured using paper-based questionnaires. Electronic-based questionnaires make it possible to aggregate and calculate the data, which is cost-effective in real-time. In comparison to traditional paper-based questionnaires, the utilization of EDC for the self-reporting of patient data potentially reduces the time to acquire data and can hence increase the patient´s compliance[11]. Further, electronically captured, self-reported patient data can instantly be compiled and can be available for physicians and clinical personnel in almost real time. This provides indications for possible medical interventions, even in-between appointments [12].

B. NFC for data acquisition e

Near Field Communication or NFC, is a short-range high frequency wireless communication technology, based on the frequency of 13,56 MHz, which enables the exchange of data between devices within 10 centimeters (around 4 inches) distance [13-15]. NFC makes many tasks easier and more convenient by providing access to systems and services simply with a touch.

Currently, there are considerable studies on various occurrences of electronic data capture (EDC) [16-21]. Although NFC is relatively novel in healthcare research, especially for home healthcare solutions, NFC is now becoming more and more popular. Morak et al. use NFC-technology as a self-management process for monitoring heart failure patients [22], and Iglesias et al. describe an NFC-based health monitoring system to improve quality of life for elderly patients [4]. Patients transmit health related data to a central database by touching medical devices with a mobile telephone. Physicians or nurses can view the entire data and guide the patient to the best possible health status. Bravo et al. use NFC for supporting nurse activities in an Alzheimer's day center [23]. NFC-based nutrition management for elderly patients is suggested by Prinz et al. [24]. In clinical context, NFC is used by various researchers. Lahtela et al. have developed an NFC-based solution to avoid medication errors in hospitals [25]. As an additional path of medical data acquisition, Fikry et al. [26] and Morak et al. [27] describe different NFC-based solutions which allow physicians or nurses to collect data by easily touching medical devices with a mobile phone.

III. inSERT Prototype System Functionalities

Users attribute an important role to the interactive applications interface design. The overall process of our approach to user-centered design (UCD) is based on evaluating the usability of inSERT in small iterative steps. We adapted the approaches of Resatsch et. al [28] and Menschner et. al [29] for system development. Both approaches emphasize the importance of integrating users in the development process early-on.

The aim of user-centered design (UCD) is to support the entire product development process with user-centered activities. It is important for creating applications which are easy to use and which fulfill the needs of the targeted user-group. A major problem in mobile user-interface (UI) design practice is that current approaches cannot directly be applied to mobile phones. According to Subramanya et al., in general, the UI should be intuitive and easy to use [30]. Studies have confirmed that the importance of perceived enjoyment plays a greater role in system acceptance than do perceived usefulness and ease of use [31, 32].

In the first steps we evaluated paper-based prototypes with students, patients and experts, and identify the needs of the users. The findings and requirements form the starting point for developing the interface concepts of inSERT.

The inSERT application is designed as an easy-to-use data input method for patients with impaired fine motor skills.

A mobile phone application that allows the reading of NFC-tags on a smart poster with NFC-enabled mobile phones is used.

The idea behind smart posters is that an object can be made interactive; it is capable of storing additional information about itself in the form of an NFC Tag. By touching a NFC-enabled mobile phone to the tag, this information can be read and displayed to the user [33].

The transmitted and aggregated data is processed and stored in the central unit of the inSERT system and can be analyzed

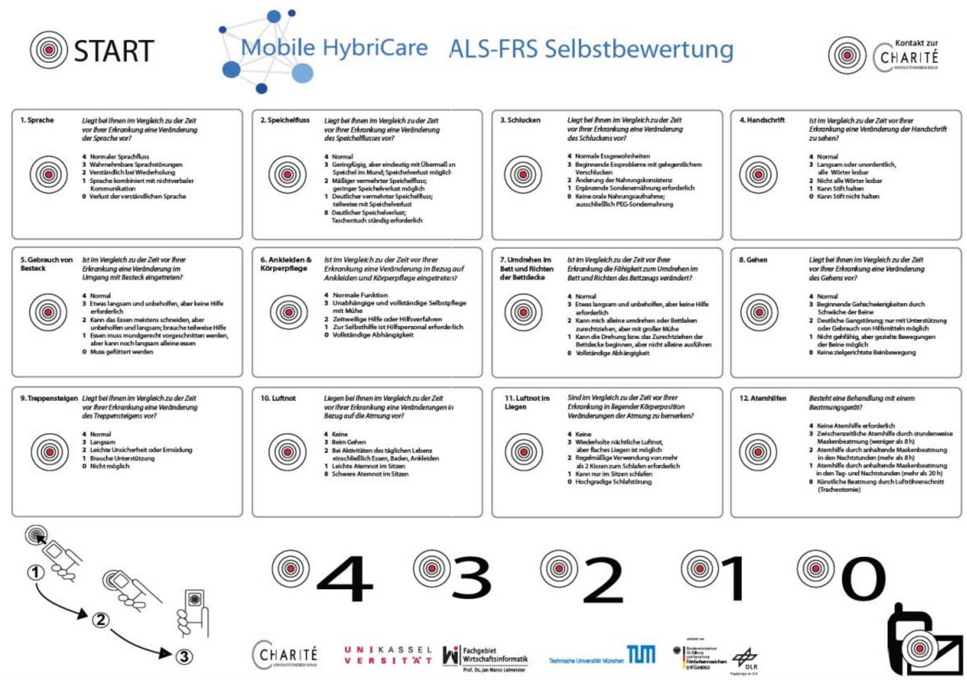

Fig. 1. NFC Smartposter for patient self-reporting

by physicians and nurses.

Our concept of inSERT is based on three main goals: (1) developing an easy-to-use service for patients with impaired fine motor skills, (2) heightening emotional user experience ("joy of use"), and (3) improving the information logistics problem between physicians, home care nurses, patients and relatives by the active participation and integration of patients, as well as better documentation and an improved basis for medical treatment and nursing care.

Figure 1 shows the self-rating questionnaire smart poster. The poster has images printed in front and NFC-tags glued to the back.

A. *Smart Poster and Mobile Application*

In current tests, we show that the NFC solution outperforms iPhone and PC-solutions, such as a paper-based protocol, with respect to the following criteria on pragmatic and hedonistic aspects. The positive scoring of NFC can be explained by the easy to learn touch metaphor of NFC interaction. This makes NFC, particularly for the target group (elderly people and people with impaired fine motor skills) who are not familiar with the use of mobile phones or computers, an interesting technology.

The smart poster contains twelve questions (three sections to bulbar symptoms, motor activity and respiratory dysfunction) with five possible answers in each case [34], as well as further buttons, such as a starting, contacting and sending button.

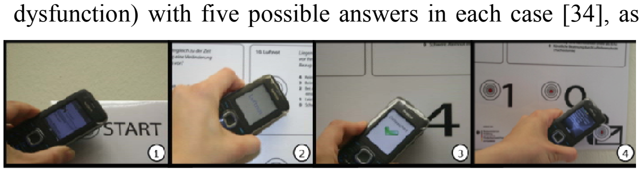

Fig. 2. NFC Smartposter for patient self-reporting

To start the application, a touch on the "start" icon or interaction field is sufficient. After the application is started, the patient has to touch one of the twelve questions. As shown in Fig 2, patients have to follow four simple steps to answer the question via inSERT.

1. Touch the "start" icon to launch the application installed on the phone.
2. Touch one of the twelve questions.
3. Touch again on the rating scale to answer the question.
4. (Step two and three is repeated twelve times)
5. Touch on the "senden" [send] tag and confirm it with a second touch to send the data to the physician.

Once contact is made, the mobile device gives audible, haptic and visual feedback to the user. For audible feedback, the title of the chosen question is spoken; for haptic feedback, the phone vibrates; and for visual feedback, the chosen headline of the question appears on the display. After each question the patient has to respond to a five-point Likert scale (0 to 4). Once the answering process for the chosen question is completed, the application reminds the patient to answer the next question. Again, the mobile device confirms the transmission of data with audible, haptic and visual feedback.

The icon of the interaction field is based on generic NFC tags [35]. To help the patients navigate to the interactive areas, the inner circle is colored red. The size of the interaction field of 35 x 35 millimeters is dependent on the used passive NFC tags.

B. *Physician Dashboard*

To allow physicians the management of the patient scoring data, a so-called "physician dashboard" has been implemented. Here, physicians can extract relevant information about their patients and the distributed cell phones. In order for the information to be available all the time, at any place, a web portal has been implemented for access by both stationary computers and smart phones. In this way, physicians have a picture of the current well-being status of their patients. The dashboard is structured as follows:

On one side there is a category 'patients' providing patient relevant data. On the opposite side there is a category 'mobile devices' referring to the cell phone data handed out.

In the 'patients' category, physicians get an overview representation of the patient data, where they can see information about all participating patients. This is where patients can be added or deleted.

Next to the personal data, such as name and date of birth, is the place where the ID assigned to a patient can be found. This ID is provided as well on the smart phone to uniquely and anonymously identify the person. In addition to the ID, the data referring to the responsible physicians can be obtained. The overview reveals who has created a specific data record and when the last changes occurred. In case more specific information is necessary, a more detailed overview is available where the portal user can retrieve the history of each patient. The display can be customized as a table or as a figure, as per the suitability of the user.

Figure 3 shows the answers of the last questionnaire entries. The diagram visualization clearly illustrates the changes in assessment of patients over their period of scoring. In addition to the content preparation for patients, the IDs assigned to dedicated patients in the category ‘mobile devices’ can be edited. Thus, it is possible to allot a certain beginning and end point when the ID can be used. The represented information also uncovers which ID is created by whom.

In addition to the access for physicians, the dashboard contains a special administrator entrance. This entrance allows assigning of access privileges to specific persons in different roles. It is thus possible to define the physicians responsible for patients, or further administrators can be allotted. The fax and phone number, as well as email address, can be stored corresponding to each contact. The administrator access also allows adding additional questionnaires. Therefore, apart from the existing system of evaluating a questionnaire concerning motor diseases, further smart poster and telemedical applications can be appended following similar principles such as patient scoring.

IV. Technical Description and Process Routine

To gather data in a centralized way and to easily monitor the data, a client server architecture is chosen. In this architecture, the cell phone acts as a client gathering the data and passing it to a server. The choice of client application, rather than purely server-side architecture, is based on the fact that, especially in rural areas, mobile communication networks

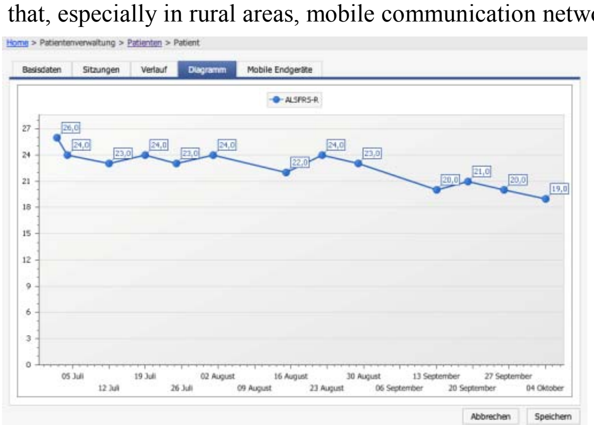

Fig. 3. Patient Scoring Data

are insufficiently developed for broadband connection needed to exchange intensive multimedia data between the server and mobile devices [36]. The client software is implemented on a Nokia 6212 classic NFC-enabled mobile phone. The communication with the web server is done by sending a HTTP request via the mobile broadband connection. The server aggregates the data and makes them available for chosen target groups.

The data-flow from mobile device to the server can be detailed as follows:

1. By touching a tag, the inSERT midlet application is automatically started, and the mobile receives the identifier of the poster. The mobile then requests an enquiry to the server. This enquiry incorporates the Poster-ID as well as a unique hash value.
2. The server matches the hash value with the ones issued to the patients. If the hash value exists, it sends the tag-IDs available on the poster to the mobile phone. This gives the phone the semantics of which tag corresponds to what meaning. There is an acknowledgement for the successful loading of all necessary data.
3. The mobile phone sends the data to the server once the patient completes the evaluation and touches the send-tag twice.
4. In this implementation, the intermediary server is first being addressed, and it eventually composes the respective messages using scripting and Java servlets.

In the hospital, the transmitted data is merged with the patient data using the delivered ID.

A. Client

The client is implemented as a Java J2ME midlet. The NFC-reader device of the Nokia 6212 phone is controlled by the J2ME midlet through an API provided by Nokia. For use in mobile devices, J2ME is used. J2ME is an optimized Java Edition for programming mobile devices [37].

The multimedia files, such as photos and audio data corresponding to the twelve questions, are stored on the mobile device. This reduces the data traffic between the mobile device and the server.

In order to start the application by simply touching the “start” tag, an NFC-Tag, storing a specific NFC Data Exchange Format (NDEF) record-type (urn:nfc:ext: wi-kassel.de:selbstbewertung) is used. The URN can be assigned to a Java class in the cell phone. If the mobile device detects an NFC tag with the stored URN, the cell phone selects the assigned java class and executes it.

If the patient wants to send a message to the hospital, he can use the email tag. By doing so, the midlet generates a special enquiry to the server co-transmitting just the ID. The server generates the email by a script and sends it to the responsible physicians allocated to the ID, who can then contact the patient.

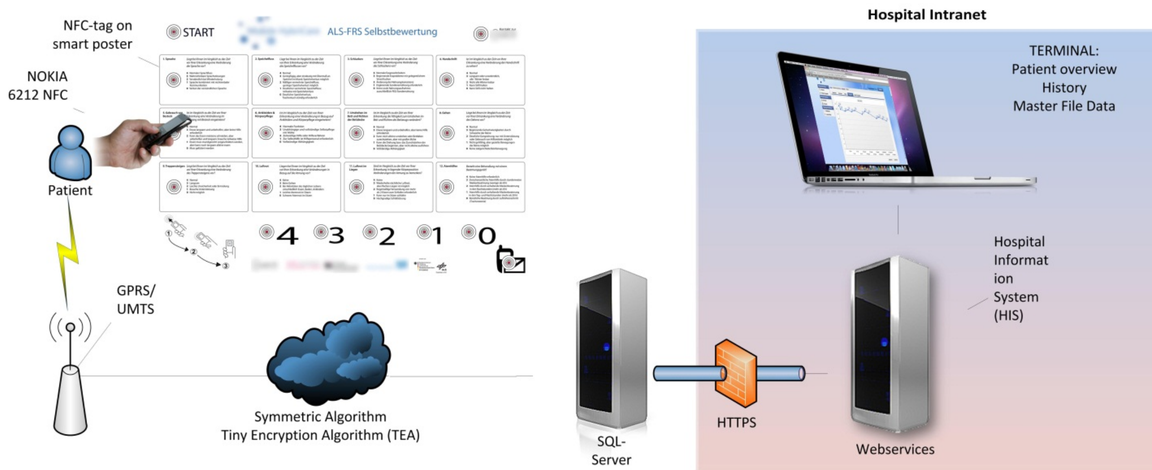

Fig. 4. inSERT Architecture

B. Backend and Security Mechanisms

The central unit of the electronic data capture solution is a server that stores the patients' response to the questionnaire and can be accessed by care-personnel and physicians through a web interface.

Since the user data contain sensitive information about patients, data security has to be considered. This is achieved in the following way:

There is separation between the master data and transaction data. Transaction data is delivered by secured mechanisms to the hospital. However, master data (in the form of information about the patients) lies in a shielded domain in a secured area inside the server architecture.

When allotting a cell phone to a patient, the cell phone gets a hash code generated in this secured area. This hash code can only be assigned to a patient inside the server, and thus during the transmission from a client to the server no personal data can be phished. To secure confidentiality of the data, it is encrypted from a client to the server. This is performed by SOAP/HTTP web services.

To address web services in an encrypted manner, the existing HTTP connection of the web services was extended with asymmetric encryption by HTTPS over TLS/SSL. The preparation of the web service communication, as well as establishing the HTTPS connection for the used cell phone, resulted in long latency times, especially in regions with insufficient radio coverage. This reduced the usability significantly. Therefore, the overload of constructing the web service messages and the asymmetric connection were outsourced to a relay server. The purpose of the relay server is to pack the received data of the clients in encrypted web service queries. The communication from the cell phone to the relay server is performed by symmetric encryption to increase the speed of transmission. The purpose of the relay server can be understood as an auxiliary means of communication as long as the rural radio coverage is not sufficient to provide the required data rate.

V. Conclusion

In this work, we adapted NFC technology to a quality of life questionnaire. We focused on engineering an easy user interaction. First evaluations show that patients accepted inSERT as a system that is easy to use and effective for reporting of the patient current condition. Through the active participation and integration of patients, better documentation and an improved basis for medical treatment and nursing care could be achieved. Further, through an intensified integration, patients gained better understanding of their medical condition and were able to more actively participate and cooperate in the treatment and consultation processes. The example of inSERT shows the potentials and possibilities that technical support systems can offer to patients.

Currently, inSERT is a fully functional proof-of-concept prototype and is being used in a long-term field study in a German hospital. Through the piloting of the prototype system, we hope to gain insights on effects of frequent system usage, e.g., a user's acceptance of technology or a possible increase in efficiency of treatment and medical consulting processes. The latter exemplary extension is based upon literature documenting that the completion of specific questionnaires enable improved forecasts of disease progression [7]. The recent integration of sensors (e.g., motion sensor) and additional technical devices (e.g., global positioning system (GPS) devices) in new generations of mobile phones additionally enables completely novel medical applications [38], that can extend our work.

To conclude, the use of mobile services and information technology can have a great impact on medical processes and services. Improvements of communication and interaction processes have a positive influence on quality of patients' lives. A modified patient-physician relationship, as a result of the improved patient information and autonomy, offers new possibilities for the design of novel medical services which are only made possible by modern technical support systems.

Acknowledgment

The inSERT prototype was developed in the context of the research project Mobile HybriCare. Mobile HybriCare is funded by the German Federal Ministry of Education and Research (BMBF - FKZ: 01FG08002). It is a joint project of the Kassel University and various partners. For further information, see www.mobilehybricare.de.

References

[1] Welsh, M., M.P. McDermott, R.G. Holloway, S. Plumb, R. Pfeiffer, and J. Hubble, *Development and testing of the Parkinson's disease quality of life scale.* Movement Disorders, 2003. 18(6): p. 637-645.

[2] Löser, C., H. Lübbers, R. Mahlke, and P.G. Lankisch, *Der ungewollte Gewichtsverlust des alten Menschen.* Dtsch Arztebl, 2007. 104(49): p. 3411-3422.

[3] Leimeister, J.M., H. Krcmar, A. Horsch, and K. Kuhn, *Mobile IT-Systeme im Gesundheitswesen, mobile Systeme für Patienten.* HMD Praxis der Wirtschaftsinformatik, 2005. 41(244): p. 74-85.

[4] Iglesias, R., J. Parra, C. Cruces, and N.G.d. Segura, *Experiencing NFC-based touch for home healthcare*, in *Proceedings of the 2nd International Conference on PErvsive Technologies Related to Assistive Environments*. 2009, ACM: Corfu, Greece. p. 1-4.

[5] Sá, M.d., L. Carriço, L. Duarte, and T. Reis, *A framework for mobile evaluation*, in *CHI '08 extended abstracts on Human factors in computing systems*. 2008, ACM: Florence, Italy. p. 2673-2678.

[6] Wolfe, F. and T. Pincus, *Data collection in the clinic.* Rheum DisClin North Am, 1995. 21(2): p. 321-358.

[7] Kaufmann, P., G. Levy, J.L.P. Thompson, M.L. DelBene, V. Battista, P.H. Gordon, L.P. Rowland, B. Levin, and H. Mitsumoto, *The ALSFRSr predicts survival time in an ALS clinic population.* Neurology, 2005. 64.

[8] Grauer, H. and F. Birnbom, *A Geriatric Functional Rating Scale to determine the need for institutional care.* J Am Geriatrics Soc, 1975. 23: p. 472-476.

[9] Guyatt, G.H., D.H. Feeny, and D.L. Patrick, *Measuring health-related quality of life.* Ann Intern Med, 1993. 118(8): p. 622-9.

[10] Strömgren, A.S., M. Groenvold, A. Sorensen, and L. Andersen, *Symptom recognition in advanced cancer. A comparison of nursing records against patient self-rating.* Acta Anaesthesiologica Scandinavica, 2001. 45(9): p. 1080-1085.

[11] Nyholm, D., J. Kowalski, and S.-M. Aquilonius, *Wireless real-time electronic data capture for self-assessment of motor function and quality of life in Parkinson's disease.* Movement Disorders, 2004. 19(4): p. 446-451.

[12] Velikova, G., E.P. Wright, A.B. Smith, A. Cull, A. Gould, D. Forman, T. Perren, M. Stead, J. Brown, and P.J. Selby, *Automated Collection of Quality-of-Life Data: A Comparison of Paper and Computer Touch-Screen Questionnaires.* J Clin Oncol, 1999. 17(3): p. 998-998.

[13] Forum, N., *Near Field Communication in the real world – part III: Moving to System on Chip (SoC) integration*, Innovision, Editor. 2007, NFCForum.

[14] Want, R., *An Introduction to RFID Technology* Pervasive Computing, 2006. 6: p. 25-33.

[15] ECMA-340, *Near Field Communication Interface and Protocol (NFCIP-1).* 2004.

[16] Bischoff-Ferrari HA., Vondechend M., Bellamy N., and T. R., *Validation and patient acceptance of a computer touch screen version of the WOMAC 3.1 Osteoarthritis Index.* Ann Rheum Dis., 2005. 64(1): p. 80-84.

[17] Richter, J.G., M. Nixdorf, T. Koch, M. Schneider, A. Becker, and R. Monser, *Mobile Computing instead of paper based documentation in German Rheumatology*, in *Proceedings of the International Conference on Mobile Business*. 2006, IEEE Computer Society. p. 28.

[18] Palmblad M. and T. B., *Electronic diaries and questionnaires: designing user interfaces that are easy for all patients to use.* Qual Life Res., 2004. 13: p. 1199-1207.

[19] Blake H., *Innovation in practice: mobile phone technology in patient care.* Br J Community Nurs., 2008. 13(4): p. 160,162-616.

[20] Dale O. and H. KB., *Despite technical problems personal digital assistants outperform pen and paper when collecting patient diary data.* J Clin Epidemiol, 2007. 60: p. 8-17.

[21] Koene, P., F. Köbler, P. Burgner, F. Resatsch, U. Sandner, J.M. Leimeister, and H. Krcmar, *RFID-based media usage panels in supportive environments*, in *18th European Conference on Information Systems (ECIS)*. 2010: Pretoria, South Africa.

[22] Morak, J., A. Kollmann, D. Hayn, P. Kastner, G. Humer, and G. Schreier, *Improving telemonitoring of heart failure patients with NFC technology*, in *Proceedings of the fifth IASTED International Conference: biomedical engineering*. 2007, ACTA Press: Innsbruck, Austria.

[23] Bravo, J., D. López-de-Ipiña, C. Fuentes, R. Hervás, R. Peña, M. Vergara, and G. Casero, *Enabling NFC Technology for Supporting Chronic Diseases: A Proposal for Alzheimer Caregivers*, in *Ambient Intelligence*, E. Aarts, et al., Editors. 2008, Springer Berlin / Heidelberg. p. 109-125.

[24] Prinz, A., P. Menschner, and J.M. Leimeister, *NFC-basiertes Ernährungsmanagement für ältere, pflegebedürftige Menschen*, in *Informatik 2009 - Im Focus das Leben. Jahrestagung der Gesellschaft für Informatik*. 2009, GI - Gesellschaft für Informatik, GI Lecture Notes in Informatics: Lübeck.

[25] Lahtela, A., M. Hassinen, and V. Jylha, *RFID and NFC in healthcare: Safety of hospitals medication care*, in *Second International Conference on Pervasive Health 2008*, C.T.f. Health, Editor. 2008. p. 241-244.

[26] Fikry, M., A. Karim, and R. Muhamad, *Integration of Near Field Communication (NFC) and Bluetooth Technology for Medical Data Acquisition System* Computational Geometry & Artificial Vision, 2006: p. 147-152.

[27] Morak, J., D. Hayn, P. Kastner, M. Drobics, and G. Schreier, *Near Field Communication Technology as the Key for Data Acquisition in Clinical Research*, in *Proceedings of the 2009 First International Workshop on Near Field Communication - Volume 00*. 2009, IEEE Computer Society.

[28] Resatsch, F., U. Sandner, J.M. Leimeister, and H. Krcmar, *Do point of sale RFID-based information services make a difference? Analyzing consumer perceptions for designing smart product information services in retail business.* Electronic Markets, 2008. 18(3): p. 216-231.

[29] Menschner, M., A. Prinz, M. Altmann, P. Koene, F. Köbler, H. Krcmar, and J.M. Leimeister, *Reaching into patients' homes – participatory designed AAL services - The case of patient-centered nutrition tracking service.* Electronic Markets, 2010 (to appear).

[30] Subramanya, S.R. and K.Y. Byung, *User Interfaces for Mobile Content.* Entertainment Computing, 2006.

[31] Moon, J.-W. and Y.-G. Kim, *Extending the TAM for a World-Wide-Web context.* Information & Management, 2001. 38(4): p. 217-230.

[32] Venkatesh, V., *Creation of favorable user perceptions: exploring the role of intrinsic motivation.* MIS Q., 1999. 23(2): p. 239-260.

[33] Forum, N. *Smart Poster Record Type Definition*. 2006; Available from: http://www.nfc-forum.org/specs/.

[34] Kasarskis, E.J., D. Scarlata, R. Hill, C. Fuller, N. Stambler, and J.M. Cedarbaum, *A retrospective study of percutaneous endoscopic gastrostomy in ALS patients during the BDNF and CNTF trials.* Journal of the Neurological Sciences, 1999. 169(1-2): p. 118-125.

[35] Arnall, T., *A graphic language for touch-based interactions*, in *8th conference on Human-computer interaction with mobile devices and services*. 2006, ACM: Helsinki, Finland.

[36] BMWi, B.f.W.u.T., *Breitbandstrategie der Bundesregierung*. 2009, Bundesministerium für Wirtschaft und Technologie (BMWi): Berlin. p. 25.

[37] Java. *What is J2ME or Java ME?* . 2010; Available from: http://www.java.com/en/download/faq/whatis_j2me.xml.

[38] Schweiger, A., A. Sunyaev, J.M. Leimeister, and H. Krcmar, *Toward seamless healthcare with software agents.* Communications of the Association for Information Systems, 2007. 19.