Telematics and Informatics 35 (2018) 815–825

Contents lists available at ScienceDirect

Telematics and Informatics

journal homepage: www.elsevier.com/locate/tele

Integrating a mobile health applications for self-management to enhance Telecare system

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ARTICLE INFO

Keywords:
Mobile health application
Self-management
Telecare
Design Science
Usability

ABSTRACT

A dramatic global increase in the pervasiveness of chronic illness has coincided with a reduction in the availability of healthcare resources, coupled with increased costs for care, forcing a fundamental reevaluation of care processes. These trends have driven interest in the use of advanced healthcare information systems and telematics applications to improve care availability while reducing overall costs, but such measures require taking an integrated approach to a range of interrelated social, economic, political and cultural impacts and challenges. Telecare technologies allow hospitals to continuously monitor biomedical indicators, while providing patients with online services such as clinical appointment scheduling, medical consulting, remote alerts, etc. Telecare has the potential to transform the healthcare industry by reducing costs, increasing quality, and enhancing patient satisfaction. The development of a real-time monitoring healthcare service model through the integration of information and communications technologies (ICT) has emerged as a research priority. This study explores the design, value creation, development and evaluation of Telecare systems and mobile health applications for autonomous health management to ensure appropriate home-based health monitoring and treatment while improving care performance. A well-defined methodology is needed to develop artifacts due to increasing disease complexity. This study develops an Android-based self-management application based on design science research methodology. The App assists users in collecting and monitoring indicators to prompt appropriate care services. This study uses individual home self-care as the basic Telecare unit to design a service model integrating six kinds of healthcare services. Usability testing is conducted to reflect five constructs: system usefulness, ease of learning, information quality, interface quality, and overall satisfaction. Experimental results support previous research findings regarding the Chronic Care Model and enhance the effectiveness of mobile-based services. Our work provides a useful reference to researchers and practitioners interested in understanding how hospitals can better facilitate more effective mobile-based technology adoption in today's e-health environment.

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https://doi.org/10.1016/j.tele.2017.12.011
Received 30 December 2016; Received in revised form 17 November 2017; Accepted 11 December 2017
Available online 12 December 2017
0736-5853/

1. Introduction

Continued advances in science and technology and general improvements in environmental and social conditions have considerably increased life expectancy over the last 50 years. In 2010, the number of people aged 60 years or over stood at 10.69%, and this proportion is expected to increase to almost 39.27% by 2060 in Taiwan (Lu et al., 2016). Population aging has profound consequences and implications for all facets of human life, including health care. For instance, the proportion of aging patients needing complex care for one or more chronic illnesses has increased (Hoffman et al., 2004; Larson and Reid, 2010). In addition, a growing shortage of primary care providers is increasing the urgency of finding new ways to deliver care to chronically ill people (Kvedar et al., 2014). Faced an aging patient base, hospitals must invest more resources into effective and efficient complex disease management.

These goals faced by hospitals can be assisted by external resources. Self-management, supporting independent living, and integrating health and social care services can enhance care efficiency and effectiveness (Barrett, 2013). In turn, continued advances in science and technology and general improvements in environmental and social conditions have increased life expectancy around the world. A shortage of primary care providers to offer affordable, high-quality healthcare for the increasing elderly population has created an urgent need to find new ways to deliver care to chronically ill people (Kvedar et al., 2014). This raises the importance of integrating medical care resources to achieve resource sharing. Hospitals need to increase operational efficiency in the prevention and treatment of chronic illness. One possible solution to the ever-rising costs and optimization of the quality of care, has been to follow a patient-centered approach. Patient-centeredness is regarded as essential for the delivery of high quality care, but more research is needed to measure the impact of processes and outcomes of patient-centered care (Mead and Bower, 2000). A growing body of research seeks to improve care for chronically ill patients through developing a service model designed to improve treatment outcomes and reduce spending in long-term care (Botsis et al., 2008b). These efforts are supported by emerging technologies such developments, such as Telemedicine, Telehealth, and Telecare (Cook et al., 2016).

Telemedicine is the use of technologies to remotely diagnose, monitor, and treat patients, while telehealth describes the application of technologies to help patients manage their own illnesses through improved self-care and access to education and support systems. Telemedicine and telehealth are currently being applied and combined to create new ways to deliver care (Stowe and Harding, 2010). Telehealth enables patients to remotely exchange vital clinical information to support the management of long-term health conditions (DoH, 2012), such as blood pressure (BP) readings. To achieve its full potential, telehealth must be integrated into traditional ambulatory and hospital-based practices, and must meet the six requirements of care quality as defined by the Institute of Medicine: safe, effective, patient-centered, timely, efficient, and equitable. Telecare is a disruptive technology that appears to threaten traditional healthcare delivery, but has the potential to reform and transform the industry by reducing costs and increasing treatment quality and patient satisfaction (Schwamm, 2014).

Telecare is defined as the use of personal and environmental sensors in the home to enable patients to remain safe and independent in their own homes while receiving care (DoH, 2012; Stowe and Harding, 2010). Barlow et al. (2007) defined Telecare as "the use of communications technology to provide health and social care directly to the user (patient)" (Barlow et al., 2007). This excludes the exchange of information solely between professionals, generally for diagnosis or referral. Consequently, Telecare is a tool to be used by healthcare professionals to deliver a user-centered services that complement rather than replace existing care delivery models. Most older people want to remain in their own homes as long as possible, and 35% of those currently living in care facilities could potentially be supported at home with Telecare (Barrett et al., 2015; Mort et al., 2013). Norway was the first country to implement an official fee schedule for Telecare, making some services reimbursable by the National Health Service in 1996 (Botsis et al., 2008a). In the UK, the Department of Health embraced telecare and has spent £80 million in preventative technology development grants since 2006, aiming to roll out telecare services nationally by the end of 2010 (DoH, 2012). When properly implemented, the broad adoption of connected health has the potential to extend care across populations of both acute and chronically ill patients and help achieve the important policy goals for improving access to high-quality and efficient healthcare (Kvedar et al., 2014).

The application of real-time Telecare has focused on home-based health monitoring, which is an extension of in-hospital services via ICT (Raikhelkar and Raikhelkar, 2015; Yousef and Lars, 2005) Care devices based on ICT include real-time visual and auditory links and relationships between caregivers and users (Huang, 2013). Dramatic increases in the numbers of chronically ill patients in the face of shrinking provider numbers and significant cost pressures mean that a fundamental change is required in care processes. Organizational and societal changes, such as cost reduction policies and population aging, are the main driving forces for the development of Telecare (Botsis et al., 2008a; Cimperman et al., 2016). We need to identify patient management approaches that would ensure appropriate home-based health monitoring and treatment of patients while improving care performance outcomes. However, few studies have discussed the development of an ICT-enabled service model with theoretical foundations in designing artifacts.

Well-defined methods are needed to allow healthcare systems to develop artifacts for managing increased disease complexity, and increased attention has focused on the development of real-time monitoring healthcare service models through ICT (Clarke and Thiyagarajan, 2008). Conversely, increasing availability and affordability of mobile communications technologies have significantly benefitted users in rural areas. As mobile technologies become increasingly ubiquitous elements in enterprise systems, scholars have emphasized physical and temporal contexts as important elements of systems design (Yoo, 2010). Some of these models establish conditions that foster the adoption of enabling technologies, including remote patient management technologies and new sensor network environments (Baker et al., 2011; Coye et al., 2009; Grant et al., 2015; Singh et al., 2011).

Healthcare communities are increasingly realizing the potential of mobile technologies to create economic opportunities and strengthen social networks. Mobile technologies effectively reduce distance between patients and expert caregivers, facilitating information sharing and knowledge transfer. This study describes the development of an Android-based health self-management application (I-health App) based on design science research (DSR), a well-defined methodology from the information systems field (Hevner and Chatterjee, 2010; Hevner, 2007; Hevner et al., 2004; Peffers et al., 2007). This method follows six major processes: identify problem and motivation, define solution objectives, design and development, demonstration, evaluation, and communication (March and Storey, 2008; Vaishnavi and Kuechler, 2015). Patients are generally satisfied with Telecare, but they typically prefer a combination of Telecare and conventional healthcare services (Botsis et al., 2008a). Consequently, this research extends our current understanding of improving care delivery efficiency by applying mobile technologies to enhance benefits in a service model (Paré et al., 2007). Even traditionally conservative healthcare providers like Kaiser Permanente and the Mayo Clinic have established separate units dedicated to improving patient experience, using design perspectives as a primary tool for innovation (Yoo and Kim, 2015). This study integrates the various strands of relevant DSR to provide a common ground from which to further develop Telecare. We develop and test the prototype systems to assess the application of theoretically supported methodologies to apply mobile technologies to care delivery, taking a DSR perspective in an Academic Medical Centre and its affiliated facilities in Taiwan, and discuss its potential societal impact.

2. Methodology

2.1. Telecare service model development

In 1995, Taiwan's government launched a telemedicine project to provide medical consultations to residents in remote areas and to facilitate communication between major medical centers and remote medical units. In addition, in 2003, the Industrial Technology Strategy was launched to respond to increasing demand for long-term care and, in 2007, a Telecare Pilot Project was initiated to promote "aging in place". Home/community and institutional-based services were developed to provide physiological monitoring, health management, emergency medical resource referrals, health education instruction, and counseling services for chronic cases. Private medical institutions were encouraged to integrate information and communications technologies (ICT) to provide related Telecare services, and telehealth information platforms were established to integrate a range of healthcare models, facilitate information exchange, and to integrate healthcare information within the healthcare system to ensure continuity of care services (Ministry of Health and Welfare, 2016).

A Telecare eco-system has been established in this interdisciplinary cooperation model comprising hospitals, healthcare systems, medical equipment manufacturers, information and communications technology operators, and network service providers. These stakeholders seek to develop a sustainable digital health industry that meets Taiwan's social welfare needs (Chiang et al., 2015). However, the development and expansion of home Telecare remains relatively sluggish in Taiwan. Previous studies have discussed success factors for implementing Telecare services (Postema et al., 2012). Policy, organization, equipment, technology, and healthcare providers' attitudes and perceptions are complex factors which affect the ability of hospitals to develop and implement Telecare services (Villalba et al., 2013). Telecare is a compound system and requires the careful assessment of related factors, and optimizing Telecare usage and providing integrated care are key issues which require additional consideration (Ekeland et al., 2010).

This research project was carried out from January 2013 to August 2014. It is methodologically based on Wagner's model of the project development life cycle and the waterfall model (Wagner et al., 1996). For the healthcare framework, we use individual home self-care as the basic Telecare unit, and the model seeks to allow healthcare professionals to provide six kinds of services, including (1) 24-hour real-time health status tracing and monitoring (2) emergency care referral and health consultation (3) home visits (4) return visit scheduling (5) prescription delivery and (6) delivery of social welfare services (Kao et al., 2012). Once the services model is established, it may be expanded to include additional equipment for measuring physiological information. The physiological information recorded from each patient is used to create a continuous report delivered via the information system (IS) to healthcare professionals for monitoring purposes. A simplified service model is displayed in Fig. 1 (Kao et al., 2012).

2.2. Design science perspective

Information systems (IS) researchers are increasingly interested in design science research (DSR) which plays a central role in the development and management of information technologies and systems (Glass, 1999; Winograd, 1996). The integration of DSR in the IS research community successfully makes the case for its validity and value, with it becoming a major component of research (Peffers et al., 2007), and is increasingly applied in IS research (Hevner and Chatterjee, 2010; Kuechler and Vaishnavi, 2008). DSR practices are aligned with the activities of IS practitioners and researchers– creating, applying, evaluating, and improving information technology (IT) artifacts. DSR is concerned with developing and evaluating new and innovative IT artifacts to solve problems and, through the process, contribute to knowledge (Hevner et al., 2004). DSR seeks to deal effectively with the complexity of real IS problems by simplifying problems and applying well-known theories and solutions. Artifacts used include constructs, models, methods, and instantiations. Hevner and Gregor suggested that both design theory and artifacts are acceptable and desirable outcomes of DSR projects (Gregor and Hevner, 2013). The results of DSR include both newly designed artifacts and an improved understanding of why the artifacts provide an enhancement (or disruption) to the relevant application contexts (Hevner et al., 2004). As a result, DSR seeks to enhance technology and scientific knowledge bases via the creation of innovative artifacts that solve problems. This study supplements the functionality of home boxes in the patient's residence to enhance data mobility. In IS, DSR involves the construction of a wide range of socio-technical artifacts such as decision support systems, modeling tools, governance strategies, methods for IS evaluation, and IS change interventions. The DSR process includes six activities: problem identification and

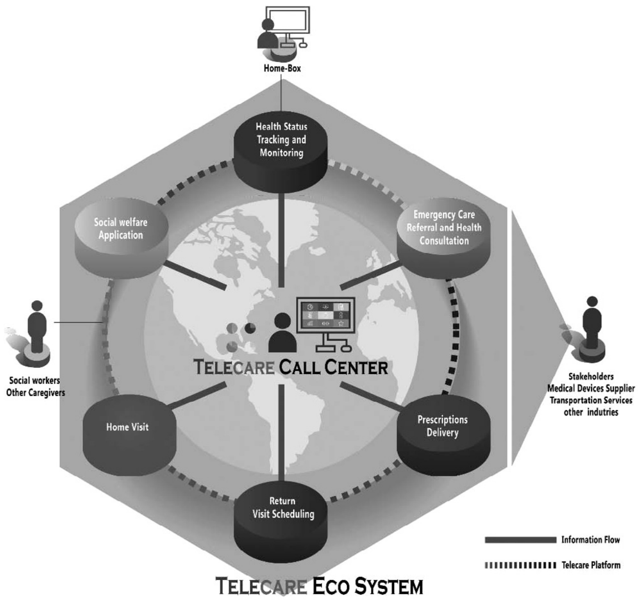

Fig. 1. Service Model and ECO System in Telecare (Reformed from Kao et al., 2012).

motivation, definition of the objectives for a solution, design and development, demonstration, evaluation, and communication. The DSR concept can redefine human experiences, leading to the development of problem solving and innovation practices that embody design thinking (Buchanan, 2015; Peffers et al., 2007).

2.3. System architecture and Software development

The implemented mobile Telecare architecture includes a home box connected to a blood pressure gauge, an Android OS smartphone associated with pervasive computing, a user interface in the smartphone and a cloud-based Telecare information system. The system can perform data monitoring and management of patient vital signs and daily activity, providing an effective interface between clinical staff and remotely assisted patients. The implemented system is presented in Fig. 2 including Bluetooth (BT) and wireless internet protocols for data communication. The smartphone serves as the main computing platform and stores the patient data. The system implements distributed data processing, with primary processing, including physiological parameters calculations, performed on the connected BP device on the home box. The intermediate processing and data representation are performed on the smartphone, while advanced data processing and database management is performed by the cloud-based Telecare information system.

This application is designed using Google's Android software stack. Android is an open source framework designed for use on

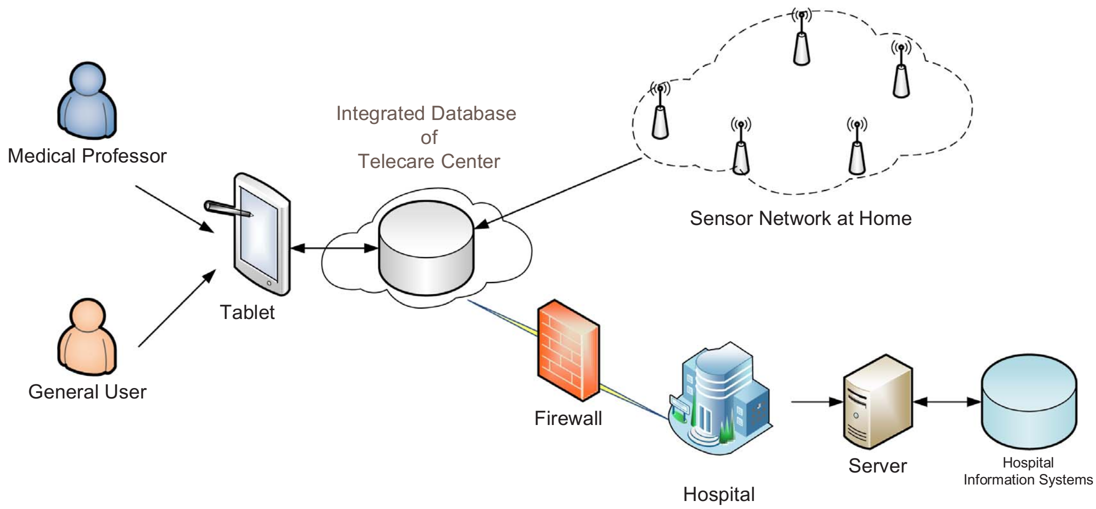

Fig. 2. System Architecture of Mobile-based Self-management Application.

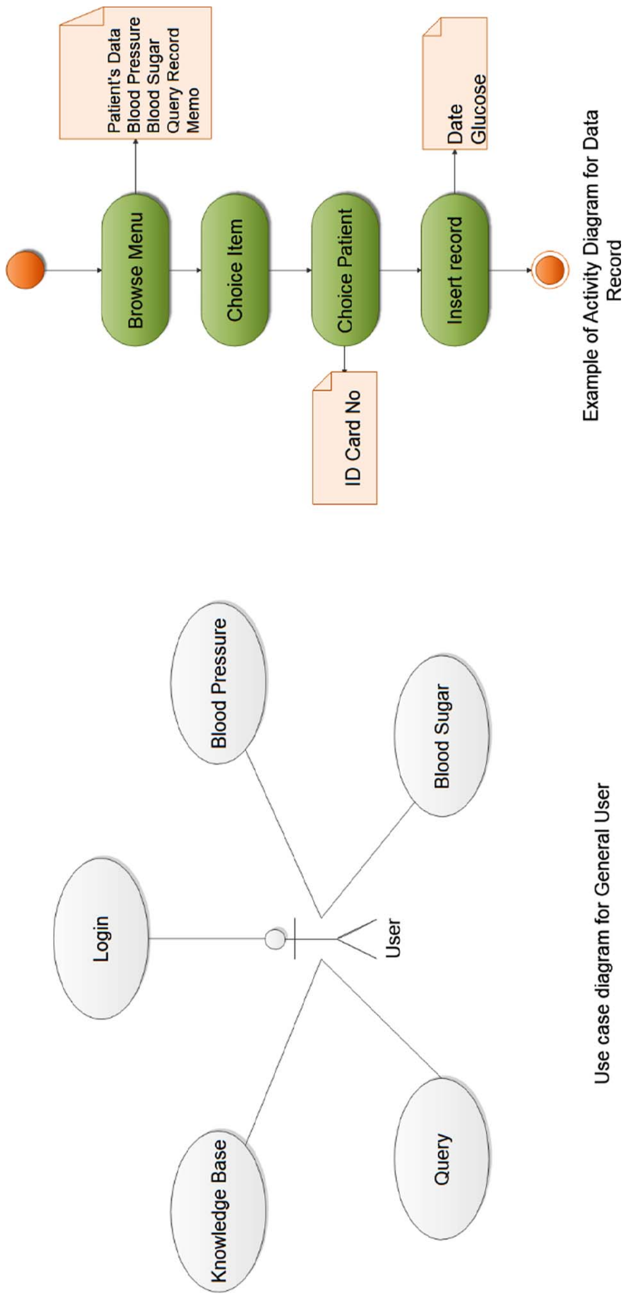

Fig. 3. Use case and Activity Diagram.

mobile devices, and includes an operating system, middleware, and key programs. The Android Software Development Kit (SDK) provides libraries needed to interface with the hardware at a higher level and make/deploy Android applications (Rogers et al., 2009). The application is written in Java and uses SQL databases to store persistent data. We chose this platform because of its ability to easily thread background running processes and its compatibility with other Android devices.

2.4. Requirement modeling and implementation

This stage acquires and models the Telecare activities (i.e., the work flow) and associated knowledge through the acquisition and classification steps. We used the unified model language (UML) approach to capture and organize requirements via interviews with service providers. Domain Analysis (DA) is also important for Model Driven Development (MDD), but traditional DA methods are not practical for many situations (Guo et al., 2015). The semantic and contextual objective metric for enriching domain ontology concepts were conducted (Kastrati et al., 2016). Finally, the knowledge of Telecare was generalized from two approaches: a use case and activity diagram in modeling, as shown in Fig. 3. The use case is valuable for goal modeling. A goal-based use-case approach was proposed to extend the use-case approach (Lee and Xue, 1999). The activity diagram is used to model the activity flow controlled by conditions and connections. A drawing represents an activity's input and output visual layout. The data glossary is used to describe the activity data information (Wu et al., 2007).

Business process flows are typically modeled with an activity diagram using UML (Schambach and Walstrom, 2003). It includes several elements: Activity, Start Activity, End Activity, Transition, Fork, and Branch, Merge, and Join. The first three elements encompass the activity. The fourth element represents the connection. Merge and Join represent preconditions. Fork and Branch represent the post-activity conditions. Although the activity diagram can easily represent a scenario, it cannot effectively represent detailed input and output information for each activity. Therefore, other tools must be used. A drawing can be used to effectively express input and output information, such as title, presentation position, lines, figures, and tables which are widely used in systems analysis and design. One data glossary record format might contain Data_type, Origin_type, Source_field, and Computing_rules fields to describe the data that make up an activity.

3. Results

This study follows the above DSR activities to develop and implement an application for the self-management of a Telecare service model in southern Taiwan.

3.1. Problem identification and motivation

This stage defines the specific research problem and justifies the value of a solution. Because the problem definition will be used to develop an artifact that can effectively provide a solution, it may be useful to conceptually reduce the problem and thus simplify the solution. An academic medical center sought to implement a database to collect and support the development of the Telecare service model. The Telecare center can use health self-management information systems to improve quality of care, user satisfaction, and operational efficiency. The application allows users to collect and display data from devices used for health self-management, and can be configured to automatically collect health management process information.

3.2. Define the solution objectives

This activity infers the objectives of a solution from the problem definition and knowledge of what is feasible. The objective of the project was to develop an artifact, referred to as the Android-based self-management application, based on the DSR. The major challenges to implementation included the collection of vital sign data from devices via Bluetooth, the diversity of objectives for which reports were generated, and the need to conform to the various requirements of users and call centers. The application provides a rich environment to promote the improvement of self-management capabilities, with a long-term goal of continuous patient monitoring and improved health self-management effectiveness.

3.3. Design and development

The artifact is created in this activity. Such artifacts are potentially constructs, models, methods, instantiations, new properties of technical, social, and/or informational resources. The selection of development tools was based on the following principles: (1) user-friendly interface, (2) ease of interface customization, availability of plug-ins, and functions compatibility, (3) system features (sending, receiving, autoreply, etc), (4) support for programming languages, (5) established community of users and developers, and (6) support for popular mobile devices. Mobile technologies have the potential to serve as a medium for strategic intervention to improve patient management. Due to the widespread use and low cost of these technologies, it pervades all age groups and socio-economic and cultural backgrounds. Fig. 2 shows the system architecture, which consists mainly of data sources, devices and tools. The system was developed using the Android SDK, and is connected to devices via BT or wireless technologies. Given these data sources, the application was developed based on the UML system analysis methodology, with examples in Fig. 3 showing case and activity diagrams for developing the user interface.

Fig. 4-1. Example of User Interfaces (Simulation data).

3.4. Demonstration

This activity demonstrates the use of the artifact to solve one or more instances of the problem. This could involve its use in experimentation, simulation, case study, proof, or other appropriate activity. In this step, it is necessary to demonstrate the use of the artifact to solve instances of the problem. Finally, the application was developed to maximize usability. The user interface present graphs and tables to assist users in presenting simplified query results, as shown in Fig. 4-1 and Fig. 4-2. In addition, discrepancies in data combinations are highlighted to instantly alert users and caregivers 26670819150of abnormal indicators.

3.5. Evaluation – usability testing

This activity involves comparing the objectives of a solution to actual observed results from use of the artifact in the demonstration. Researchers observe and measure how well the artifact supports a solution to the problem. Usability has been defined in a number of ways, mostly as a construct based on a variety of attributes. Usability attributes suggested by Nielsen include learnability, efficiency, memorability, errors, and satisfaction (Nielsen, 1999), while Shackel (1991) proposed effectiveness, learnability, flexibility, ease of use, and user attitudes. By looking at how users themselves defined usability, McGee et al. (2004) identified a number of attributes including consistency, efficiency, ease of use, effectiveness, controllability, usefulness, expectability, and naturalness (McGee et al., 2004; Shackel, 1991). Usability testing was conducted with participating users for completeness, correctness (i.e.,

Fig. 4-2. Example of User Interfaces (Simulation data).

Table 1
Factor Loadings and Composite Reliability of Constructs.

Construct	Loadings	Composite Reliability (AVE/Cronbach's α)
System usefulness	0.759–0.810	0.799 (0.674/0.765)
Ease of learning	0.816–0.849	0.886 (0.665/0.811)
Information quality	0.761–0.827	0.867 (0.625/0.843)
Interface quality	0.819–0.861	0.871 (0.724/0.815)

effectiveness), and usefulness. The objective of usability testing was to assess the application's strengths and weaknesses, and to improve usability. Table 1 shows the four constructs and 15 measurements.

Based on previous discussions, all survey constructs were measured using multiple indicators. Item loading, reliability, convergent validity, and discriminate validity were assessed for the latent constructs through confirmatory factor analysis (CFA). Items should be one-dimensional in their representation of latent variables, and therefore mutually correlated. Factor loadings of scale items should exceed 0.707, and the results in Table 2 show that all the variance is captured by the constructs. All constructs in the measurement model exhibit good internal consistency as evidenced by their composite reliability scores, ranging from 0.801 to 0.878.

To assess discriminate validity, (1) indicators should load more strongly on their corresponding construct than on other constructs in the model and (2) the square root of the average variance extracted (AVE) should exceed the inter-construct correlations. The presence of variance captured by a construct is given by its AVE. The PLS method was applied to evaluate discriminant validity of the major constructs of the conceptual framework. As shown in Table 3, all constructs meet this requirement. The values for composite reliability are all above the suggested minimum of 0.70. Thus, the convergent and discriminate validity of all constructs in the proposed conceptual framework can be assured.

This study adopted the Post-Study System Usability Questionnaire (PSSUQ) proposed by Lewis (1995) to assess usability and satisfaction for information system use (Lewis, 1995). The contents of PSSUQ were constructed to measure usefulness, ease of learning, information quality, and interface quality, with the evaluation constructs listed in Table 3. The PSSUQ survey was used to obtain feedback from users who had completed the specific tasks. The questions were answered using a scale from 1 (strongly disagree) to 7 (strongly agree). This study recruited 47 respondents (Male = 29, Female = 18; over 65, N = 21, 44.7%; telecare services use for over 1 year, N = 27, 57.4%) from the medical center's Telecare Center. This telecare center was setup in 2010, and as of 2016 is used by approximately 300 patients. The "I-health App" was found to assist users in collecting and monitoring indicators, thus increasing work efficiency. The results show a clear need to collect and integrate data across different departments. For example, using the I-health APP's user-friendly interface and functions to generate easily understood reports. The results also indicate that ease of use and interface usability are critical factors in improving work efficiency and streamlining the debugging process.

3.6. Communication

The final activity is concerned with communicating the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness for researchers and other relevant audiences. Therefore, this project was presented to various technology-oriented and management-oriented audiences. Research on I-Health App has been published in The MIS Quarterly and Journal of Medical Internet Research, and the present work was presented at Medical Informatics in Europe (MIE) 2012 and the 27th International Conference on Industrial, Engineering & Other Applications of Applied Intelligent Systems, and feedback received at these presentations has been addressed in the current article. From the practical viewpoint of healthcare administration, we have demonstrated how mobile techniques and tools can be used in non-traditional areas of the health care environment to allow caregivers to make informed decisions to improve resource allocation and quality of patient care. To gain further insight into the usability testing results, we conducted post-use interviews with 6 respondents, including the hospital's vice-superintendent, Chief Information Officer, a senior manager of the Telecare service, and 3 general staff, each of whom have over 3 years of experience in Telecare provision.

4. Discussion

This study suggests that information systems theory (e.g. DSR) and practice can inform product creation as well as the intended or actual utilization of the finished product. We exemplify the integration of IS behavioral science and user participation in the design

Table 2
Descriptive Statistics and Inter-correlations among Major Constructs.

Constructs	Composite Reliability	1	2	3	4
1. System usefulness	0.799	0.812			
2. Ease of learning	0.886	0.455	0.849		
3. Information quality	0.867	0.212	0.351	0.837	
4. Interface quality	0.871	0.385	0.503	0.321	0.834

Table 3
PSSUQ measurement items and results.

Measurement	Results (Mean ± SD)
System usefulness	5.12 ± 1.51
Ease of learning	5.47 ± 1.43
Information quality	5.15 ± 1.41
Interface quality	5.37 ± 1.21
Overall satisfaction	5.47 ± 1.48

science process by addressing adoption and diffusion variables found to be significant in the general Telecare context with the I-Health App, an easy user interface aimed at improving affective distance communications between patients and healthcare professionals, with particular emphasis on monitoring patient emotional state in a healthcare context. Telecare settings provide a rich landscape for research and the application of affective computing to improve the quality of patient care, and I-Health has the potential to make a significant contribution to this end. The current study is based on two major technologies; smart mobile phones and sensor networks. We tested the sensor network in a closed and controlled environment, and the fact that participants met in person seemed to have helped create meaningful bonds that are absent in a general healthcare sensor network. Sensor networks are an excellent tool in self-management as shown by our developed mobile applications.

This study develops an application based on an IT-based service model which extensively improves the efficiency and effectiveness of patient management. The resulting mobile-based technology and evolving new development tools (e.g., Android-based mobile devices) can then guide the relevant activity in relation to the development of information systems. Healthcare professionals can also use patient profiles in the system to make clinical decisions based on the degree of illness severity and development needs. The realization of I-Health to fulfill this promise may be contingent upon the various interface, adoption, and implementation issues determined through qualitative field methods. The underlying theme of introducing IS theory and field study practices to the design science process is that future iterations of I-Heath App, input and output user interfaces and related processes should enhance rather than replace the existing reality and systems, and can be applied to other medical purposes in the Telecare context.

This paper summarizes the processes of design, development, and implementation of a remote management system using mobile technologies to help patients to improve self-management following treatment. The system comprises an application layer for the capture and delivery of patient information, including collection of vital sign from a home box or sensor network, which are then relayed to a remote server over the internet. The server generates and transmits personalized data to patients, healthcare professionals, case managers. An interdisciplinary group of researchers were involved in the design, development, and implementation processes to enhance system utility and functionality. Several conclusions are derived as follows:

First, mobile-based technologies offer a means of making care more affordable, and have been shown to support patient self-management, enhance cooperation with caregivers, shift responsibilities to nonclinical providers, and reduce the need for emergency services. Transformative mobile technologies offer major opportunities to improve the quality and efficiency of healthcare at a national scale, making it important to understand the evolution of such technologies, the experiences of early adopters, and business models that may support their sustainable deployment.

Second, the service model could be used to effectively monitor risk of disease occurrence when patients are at home, and provide real-time emergency alerts. Moreover, compared with traditional care service models which rely on passive information, the proposed approach allows healthcare professionals to actively intervene through mobile-based technologies.

This study is subject to at least two limitations. First, our participants were recruited from an academic medical center's call center. Therefore, it is possible that these individuals are more highly motivated to use mobile technology than other patients. Second, this study was based on a comparatively small sample. Although it is difficult to generalize about the significance of the health outcomes from such a small sample, our qualitative analysis provides useful feedback on aspects of system design such as usability testing. Although the system was designed specifically for a case study, this development strategy can be generalized to other ICT-based interventions.

5. Conclusions and future work

In conclusion, our findings have potentially important implications for users seeking to benefit from mobile-based applications. The proposed service model is based on the use of mobile platforms, and can facilitate the integration of available healthcare services, enhancing flexibility and efficiency of service delivery. While numerous advocates have prescribed such a collective responsibility as a normative guideline, our research provides empirical support for this prescription. These findings are consistent with previous research proposing a Chronic Care Model (Wagner et al., 1996). We found the important perspective about the social impact of smart technologies, such as mobile technology. The introduction of advanced technology into the home has the potential to change qualitative and quantitative features of relationships between household members, as well as the role and function of the home and its relationship with the varied environment. Such technologies consequently have important implications for our health and quality of life (Demiris and Hensel, 2008). Our work provides a useful reference for researchers and practitioners interested in learning how hospitals can facilitate more effective adoption of mobile-based technologies for e-health. We expect that our design science perspective and findings will stimulate and encourage more research in this field.

This study presents a single case, and various remote healthcare platforms operating under different business models. Although this study provides an integrated platform solution, the settings are determined from the standpoint of online platform operators. Others seeking to enter this industry, building their platforms from scratch, will have to determine how to best use their particular operating advantages in terms of their customer base, service offering and personnel arrangements. Efficiency and usability measurements often require production-ready systems to be in place for proper evaluation, which often take years to develop. It is no surprise, then, that costs for healthcare have been progressively growing in the last decades (Spruit et al., 2014). Therefore, the results of the present study may not be applicable to the operation of all remote healthcare platforms, and follow up research is still required for various enterprises and operating platforms, along with multiple case studies, to provide a more comprehensive and detailed solution. Therefore, future development work should account for interface design theory, and usability testing can conduct to assess the effectiveness of platform-based interaction. Such efforts will not only increase usage frequency, but also enhanced perceived usefulness and ease of use, thus driving user satisfaction and creating new customer value.

Acknowledgements

This project is supported by Ministry of Science and Technology, Taiwan (MOST 105-2511-S-037-002 & MOST 106-2511-S-037-003 & MOST 106-2511-S-003-029-MY3) and affiliated grant NSYSUKMU106-I005 from National Sun Yat-sen University and Kaohsiung Medical University in Taiwan.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.tele.2017.12.011.

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