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Telemedical Services for Home Rehab

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Abstract: This paper presents a framework of new telemedical services for home-based rehab. The importance of home rehab is fast growing due to increasing cost pressure. A sustainable treatment at home is currently ineffective. By deploying an integrated usage of information and microsystem-based technology a sustainable rehab is getting possible at acceptable costs. This paper presents such a network oriented approach including patients, rehab clinics, family doctor and medical service providers (MSP). Latter are responsible for collecting, summarizing and editing of the patient's data. Vital signs such as blood pressure or pulse are measured by micro sensors and transferred into a central database. Authorized network participants, such as the rehab clinic or the patient itself, continuously monitor these parameters. Beyond the medical and cost advantages, this also creates new service offers and business models for telemedical application and service providers.

Keywords: telemedicine, micro sensors, homely rehab, medical services

1. Introduction

Numerous medical procedures require subsequent patient care in a rehabilitation clinic (rehab clinic) in order to re-establish a state of health that enables independent coping with daily life. The number of patients is growing rapidly. One reason for this increase is the demographic change almost all industrial countries are faced with. However, especially elderly patients want to be able to take care of themselves and pursue hobbies or jobs as soon as possible following an illness [1][2][3]. Rehab clinics are currently not able to cope with these claims. The need of process efficiency and effectiveness of rehab clinics as well as other medical service providers is strongly increasing due to an exposure to an enormous cost pressure. This caused a 25% shortened duration of the hospital stay within the last 15 years ([4], see Figure 1). However, from the patient's point of view, shortened duration of stay with limited aftercare complicates a quick and safe recovery.

The extensive or complete recovery at home is usually no longer supervised by doctors or the rehab clinic, but by the patients themselves. A monitoring of rehab success indicators is performed only sporadically, and an adaptation of rehab plans to the current ADL value (activities of daily living) rarely takes place.

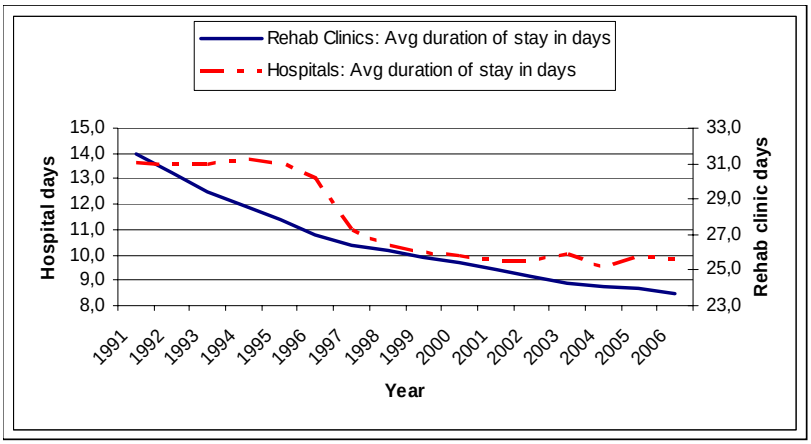

Figure 1: Average Duration of Stay in German Hospitals, 1991-2006 [4]

Therefore, patients require intensive support beyond there inpatient stay (after phase 2 in Figure 2). This has to be done by rehab specialists who can also adapt to the short cycle rehab plans. Rehabilitation measures which are telemedical supported and adapted to the state of health (ADL value) of the patient will provide important benefit. On the one hand even merely individual singular approaches exist in this context (see e.g. [5]). On the other hand holistic approaches or elaborate service offerings, addressing outlined patient needs, are missing. However, the first two phases ("acute treatment" and "stationary rehabilitation") of the recovery process are well supported. "The third phase – the post convalescence – has gained attention only in recent years. However, there is a current lack of conclusive concepts for an effective and long-term tertiary prevention across Phase 3 of the rehabilitation" [6] (Figure 2).

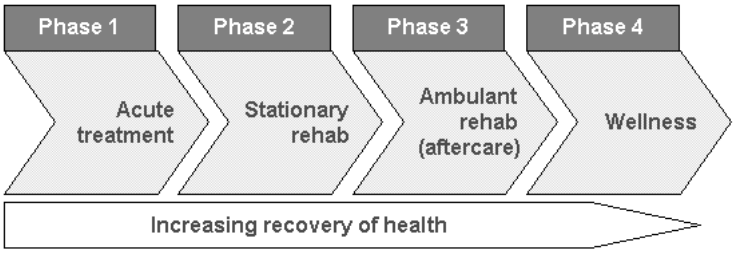

Figure 2: Recovery Process: Division in Phases

The goal of this paper is to present an intelligent integration of available applications into a complete service system that also encompasses the sensory technology for vital signs and leads to a merging of the two last phases, "ambulant rehab" and "wellness" (see Figure 2).

2. State of Research and Medical Applications

2.1 State of Research

For the implementation of an integrative solution for the support of the rehab process by an innovative constellation of technical and organizational methods and systems some different fields of technology must be considered. Recent development and current conditions will shortly be introduced in the following.

With the establishment of the first networks of the integrated health care in 2004 a demand for systems emerged for IT systems providers, to support the cooperation of different medical service providers[i]. Although at present the majority of providers of hospital information systems develop products for the support of these frameworks, the

heterogeneity of more than 100 different information systems of hospitals and surgeries on the German market represents a substantial limit for larger benefits. By input of the legislator and supported by the activities of the project "bIT4health" (better IT for better health), a framework architecture for telemetric in the health service is currently developed. Thereby a standard is created, which will permit the exchange of clinical information between heterogeneous IT systems of different service providers.

The insufficient arrangement and coordination applies with a portion of 23% as the largest source of treatment errors. Coordination errors are caused by lack of communication between ambulatory and stationary sector and by insufficient arrangements between established physicians by same parts. Additionally, lack of documentation (20%) and acts of contributory negligence (13%) play an important role [7]. For this reason the IT industry concentrates at present on applications and services in connection with the so-called electronic patient document.

A multiplicity of studies and projects comprehend the collection and transmission of individual specific vital parameters (electrocardiogram (ECG), blood sugar mirror, body weight etc.) from the home environment of the patient to the treating physician. Beginnings to the telemedical aftercare in the range of the cardiology were developed in the project NOPT (New eastern westphalian postoperative therapy concept). These beginnings which are focused on the implementation of an integrated instruction and training program as well as an integration of rehab clinic and the family doctor are further pursued in the project AUTARK (Ambulant and telemedical supported follow-up rehab after the first cardiac incident) of the “Institute for Applied Telemedicine” (IFAT). The project is using a mobile ECG equipment, which in emergency situations can derive an ECG and transfer this to the physician team of the IFAT [8]. An integration of these telemedical solutions in holistic structures is not investigated till now. Accordingly descriptions of service and business models are missing, which support integrated medical service providers.

For the observation of cardiovascular risk patients several microsystem oriented sensor technologies can be used. For some disease patterns the specific weight of the urine, as well as its microbiological and biochemical composition are of large medical interest. For the examination of therapy success with orthopaedic or accident surgical patients the mobility and maximum stress of certain joints or groups of muscles can be seized by suitable medical technology. With pneumological predisposed patients an examination of the lung function as well as individual lung volumes is meaningful. Tumor patients and patients under medication with high adverse reaction can profit from a small meshed control of their blood and in particular their leukocyte values. Also the use of devices can be supervised and evaluated, like artificially respirating masks with the help of microsystem oriented technologies (see [8], [9], [10], [11], [12], [13]).

2.2 State of Medical Application

With a multiplicity of diseases and injuries a two stage medical support is indicated by patients: After medical acute supply in the form of operations or other therapeutic interventions in the hospital, the patient is supplied for subsequent welfare treatment in a rehabilitation hospital, in order to re-establish the physical functions [14][15]. The desire to be active and be independent in daily life is very frequent even with older patients [1]. Therefore they would like to return after final rehab into their domestic environment as fast as possible. They are motivated and interested to take care for their own and to pursue their work activities or hobbies [16][17]. The rehospitalisation of a rehab patient or only a temporary stay in a nursing home, the so called "turning door effect", should be avoided also for economical reasons [15][18]. Main indications for rehab therapy are cranio-

cephalic injuries, cardiac infarcts, oncological illnesses, polytraumata, spinal column injuries as well as certain psychiatric illnesses. Due to positive correlation of the mentioned illnesses with the age and with consideration of the current demographic development it is to be forecasted that the incidences of these illnesses continues to rise [19]. Many of the patients, who will be released from a rehab stay, need further a small meshed medical aftercare [20][21]. A current study of the institute for hospital management in Münster (IKM) to rehab and Diagnosis Related Groups (REDIA) points out that in the last two years the total duration of stopover of orthopaedic and cardiologic patients decreased around 11 % after introduction of the case based lump sums. Panel patients, who constitute the majority of the patients, are mostly affected by this trend [18][22]. The rehab clinics seem to be overstrained with that increasingly early dismissal into the stationary follow up treatment. Frequently when dealing with such enfeebled patients it must be accepted that they cannot immediately start with the treatment. Therefore the rehab measures start later and consequently have to be more briefly. Patients have to be released from the rehab clinics, at a stage where it would be important from the medical point of view, to continuously control the recovery of the patients [23]. Due to these circumstances a medical monitoring of the patient's state of health has to be ensured at home as well. A critical state of the patient's health must be promptly recognized and impending complications should be observed [24]. The support of the patient by the family doctor is insufficient. Regular home visits by the physician are hardly possible for temporal or monetary reasons for the physician or the clinic he worked for. Likewise it can hardly be required from the patients to visit their family doctor or a rehab clinic in short time intervals [25].

Altogether it has to be stated that various single solutions for the microsystem oriented patient monitoring are developed. An advanced progress can be observed at this topic. Indeed, an integration of several sensors for a comprehensive multivariate monitoring of the patient status is however not pursued at present. Current research and development activities in healthcare are limited to the design of platforms for the data transfer between medical service providers focusing on the optimization of administrative processes. However, the immanent potentials of integrated healthcare for the extensive integration of the patient and their domestic environment into the healthcare delivery system currently remain unconsidered.

3. Methodology

Based on rehab treatment trends new systems that not only cover the need for clinical information are necessary. These systems do have to enable technical and economical institution spanning, patient centered treatment processes and value adding services for the improvement in the quality of life.

To solve these requirements stated above a holistic approach is presented. It integrates innovative information and microsystem technology. Accordingly new healthcare services and business models must be developed to support therapy for elderly persons in the domestic environment. One of its core objectives is the integration of various devices for the capturing of vital signs and linking them to a central database via the internet, e.g. in a rehab clinic. Therefore, organizational and technical partial solutions are introduced and combined to an overall concept based on the developed platform.

Microsystem technology already includes many innovative devices and programs that can determine different vital signs. An integration of the components and the specific implementation in rehab pre and post care has not yet been realized. Because of a strong practical orientation of the mentioned challenges an interaction of case studies and action research affects this methodical approach. Based on the technological potential of micro-

systems technology, a method of integrated technology and service planning for telemedicine in rehab treatment is developed in our contribution. In order to actually establish a new technology supported service in the market, new business models taking the particular challenges of technology investments and service sales into account, are often necessary. The contribution will introduce a new concept for this aspect as well. The integration of leading companies and research institutes in innovative information and microsystem technology and combined with a local university hospital and a rehab clinic ensures the development of innovative solutions with high practical value.

4. Approach for PC-based Telemedical Services for Home Rehab

Since neither patients nor hospitals can or want to worry about the technical development of sensor systems, telemedicine applications, IT integration etc., the approach (its structure will be shown in Figure 3) considers the technical, economical basics as well as possible business models for extended telemedical services with new and innovative methods. The potentials of the microsystem technology as well as innovative information and communication technologies will be used for a systematic planning of telemedical services. They form the basis for comprehensive (tele)medical and patient centred services. For telemedical services, the continuous monitoring of a patient's vital parameters is a basic requirement. In addition to low interference with patient's daily life, microsystem technology meets this demand to an excellent degree. Significant parameters for the support of the rehab process can be continuously monitored by the use of new microsystem technology devices and create the prerequisites for improved service delivery by rehab specialists. Furthermore, microsystem sensors afford monitoring of the proper usage of medical devices, e.g. respiratory masks, the recording of respiration times and the activity of implantable cardioverters or defibrillators (ICD).

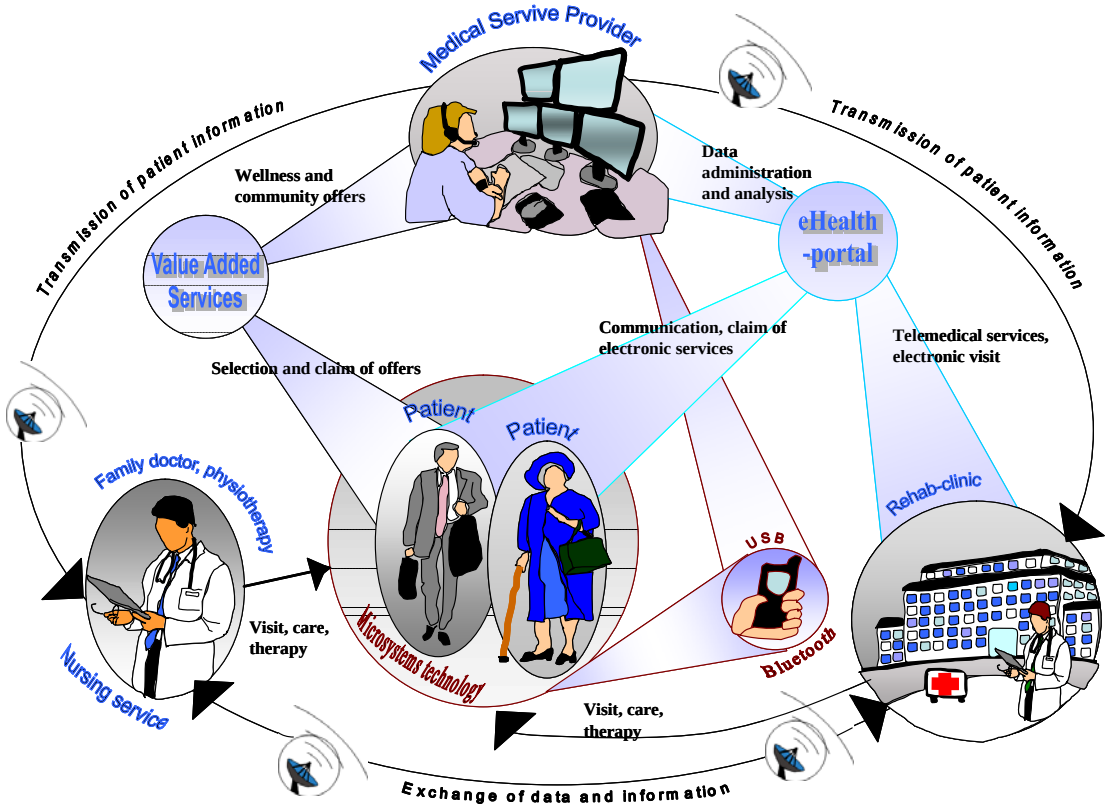

Figure 3: Holistic Solution for a Scenario of Microsystem Supported Medical Services in Medical Aftercare

Data transmission to the medical service provider takes place in an easy accessible way, e.g. by using a modified PC and a broadband internet connection or a mobile phone. The MSP's central web-based platform provides various basic services, taking privacy protection requirements into account. The collected patient data are regularly evaluated in the rehab clinic and analyzed by specialists. The evaluated and assessed data are also available to the patient via the internet.

This holistic approach of combining the possibilities of new microsystem technology and mature information technology leads to a multiple patient monitoring at the domestic area offering a concept for a modern, secure and networked rehab medicine. The system enables success measurement, which is important for both patients and the rehab clinic.

Rehab plans can be adapted to the patient's individual recovery process based on daily data. Patients can continuously measure their own progress and their personal fitness, thereby experiencing a sense of achievement. Telemedicine support by rehab clinic's specialists enables new individual services, such as electronic ward rounds or personal fitness programs. The collection and transfer of vital signs enables the rehab clinic to adapt its stationary and ambulatory catalogues of measures according to their effectiveness.

5. Business Case Demonstration of Benefits

In the following we would like to present our approach based on a business case. All costs mentioned below are approximate values resulting from first expert talks. Cardiac infarction or post-stroke patients are of special interest. To bring out the whole concept of the project we regard exemplarily a 61-year-old post-stroke patient. Since a minor stroke occurred 3 months ago the patient suffers from a temporary paralysis of his left foot and arm. Thereby, the patient is temporary handicapped and has to work on the recovery of his motion functions. After staying in the hospital for the acute, stationary treatment, the patient can:

1. Remain in the hospital or move to a rehabilitation clinic for a stationary rehab program.
2. Leave the hospital and use an ambulant rehab service in a nearby rehab clinic.
3. Making use of the new electronic "Homely rehab" service of his rehab clinic.

Our patient is interested in a quick and sustainable recovery of his health. Additionally the patient is also interested in the overall costs. Consequently the patient also calculates the respective financial advantages of the 3 options above.

Option 1 is the most expensive alternative: Our patient knows from his former workplace, each day in hospital costs over 330€ per day. His clinic doctor proposed him a stay of 4 weeks in hospital which would result in overall costs of over 9200€. Let's assume that the patient will be fully recovered after this stay. But besides the high costs of this alternative, the patient regrets not to be at his domestic environment. Additionally the patient will have to continue with home exercises, but without continuous monitoring by a doctor, after his inpatient time.

Choosing option 2 would mean to travel daily (5 days a week) to the clinic and back. In addition to this uncomfortable trips, the rehab costs of such ambulant treatment is about 200€ per day. Assuming a 6-week therapy, this would make total costs of about 7500€. Furthermore, negative consequences for his recovery process can be assumed because of the daily transfer to the clinic and back.

At first glance, option 3 will be very irritating to our patent. His doctor elucidates the procedure: Our patient will receive two different micro sensor devices. One will record his blood pressure, blood values and his pulse. The other will observe his weight and his body fat ratio. By monitoring these parameters, it is possible to evaluate and to document the patient's process of recovery. In case of an emergency, e.g. a thrombosis or a second stroke, the sensors will trigger an alarm.

The sensor's data is continuously transmitted to a medical service provider. Once a day, all parameters are checked by a rehab clinic's home rehab expert who is able to access his data, and every second day our patient is interviewed about his state of health via telephone. Every Monday, some tests are performed at the rehab clinic. Overall, this causes average costs of 75€ per day. Because this way of treatment is very cost-effective, the treatment is extended to 8 weeks and 7 days a week. This sums up to total costs of 4200€, incl. micro-sensors, data transmission and administration, monitoring, travel costs and clinic rehab.

To summarize option 3 seems the best choice. With the help of the microsystems engineering supported "Homely rehab" a sustainable, comfortable and safe treatment can be provided. The medical service provider is satisfied to offer a cost effective solution that can also assure comprehensive supervision and by this the best rehab possibility for the patient. In the end this approach creates a "Win-Win" situation for the patient and the rehab clinic.

6. Conclusions and Outlook

Numerous medical procedures require subsequent patient care in a rehab clinic in order to re-establish a state of health that enables independent coping with daily life. Because of the consistent and fast growing number of patients and the enormous cost pressure rehab clinics are faced with, an optimal care during and after patient's stay in a rehab clinic can not be warranted any more. This paper shows a way to disburden rehab clinics and upgrading the state of health of the patients.

An important component of this approach is the integration of various devices for the capturing of vital signs (e.g. blood pressure, pulse, blood sugar) with a database in a rehab clinic via the internet. This lays the foundation for the introduction of new healthcare services and business models through the integrated approach of innovative information and microsystem technology. The development of new medical services and an increased service quality at equal or perhaps even lower costs is the consequence. This approach will be developed and evaluated during 3 years within a nationally funded research project starting in autumn 2008. The project will be conducted by a consortium of research organisations, technology partners, service providers and different rehab clinics. The evaluation shall approve that the presented methodically approach leads to a better rehab of the patients associated with a higher state of health and a better competitive ability of the rehab clinics. To summarize, both patients and rehab clinics have an advantage by further research during this project.

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[i] The “Integrative Health Care” is a new approach, established in Germany in 2004, to extend the possibilities of collaboration of different medical service providers, such as clinics or practising doctors. It strengthens the networking between different medical fields (e.g. surgery or internal medicine) and sectors (e.g. clinics, family doctors or specialists).