MOBILE EMPOWERMENT OF PATIENT BY AN INTEGRATED ICT ENVIRONMENT

WZMOCNIENIE MOBILNOŚCI PACJENTA POPRZEZ INTEGRACJĘ PRODUKTÓW INFORMATYCZNYCH

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ABSTRAC

Integration of Information Communication Technology (ICT) products from different manufacturers to provide friendly support for patients and health professionals is a challenge for organizational, legal, and technological interoperability. To empowerment of patients over 65, it is necessary to support them with proper ICT tools. There are many technological solutions in e-Health sector, which do not support the patient's complex needs and standards. The CareWell project adapted a formula based on the acquisition of commercial ready-made applications that support the functionality defined for patients, doctors, nurses and the Contact Centers (Call Centers). Lessons learned from the CareWell project phases from beginning of the business processes modeling with their modification for the project needs, as well as mapping of the available functionalities of selected IT platforms, work integration and implementation, are discussed in the paper.

Keywords: telemedicine, mobile technology, integration ICT system

STRESZCZENIE

Integracja produktów informatycznych pochodzących od różnych producentów w celu dostarczenia przyjaznych usług pacjentom i pracownikom ochrony zdrowia stanowi wyzwanie w zakresie rozwiązania problemów interoperacyjności organizacyjnej, prawnej i technologicznej. Aby pomóc pacjentom powyżej 65 roku życia, konieczne jest wsparcie ich potrzeb zdrowotnych technologiami ICT (ang. *Information Communication Technology*). Istnieje wiele rozwiązań technologicznych w sektorze e-Zdrowia, które jednak nie obsługują złożonych potrzeb z uwzględnieniem standardów. Project CareWell przyjął formułę realizacji opartą na nabyciu gotowych aplikacji, które pozwalają na realizacje zdefiniowanych funkcji do obsługi pacjentów, lekarzy i pielęgniarek oraz centrali kontaktowych call center. W pracy omówiono główne wnioski z realizacji poszczególnych faz projektu od początku zamodelowania procesów biznesowych, konieczną ich modyfikację dla potrzeb projektu, jak również mapowanie dostępnych funkcjonalności integrowanych wybranych platform IT.

Słowa kluczowe:telemedycyna, technologie mobilne, integracja systemów ICT

1. Introduction

Senior patients may be supported by mobile devices and that is a subject of a field called m-Health (mobile health). So far, Polish patients are provided with medical care within the current health care system, mainly without any ICT support, in both: delivery of care and share of information. To achieve the objectives of the CareWell Project (http://carewell-project.eu/regions/lower-silesia-poland.html) (grant agreement no: 620983) necessary scenarios and business model processes have been implemented. The main objective of this Project is "Multi-Level Integration for Patients with Complex Needs". Therefore, the system design involves the integration of three subsystems: Educational − Information Platform (Mobile/Social), Integration Platform (Service Buss) and Monitoring Platform. All the integrated subsystems should fulfill specific requirements, depending patient's status [1].This approach is compatible with current trends towards cost reduction in health care [2].

Requirements for the Project have been identified at the stage of preparation for implementation and then, were transferred into the Business Process Modeling (BPM). This model was consulted with specialists and their approval was followed by the implementation of telecare process. The Integration Platform is mainly supposed to implement the telecare in accordance with the modelled procedures and allows for an adequate response in any situation. It was done by using the Application Programming Interface (API) to give applications access to connect and essentially communicate with other programs. Another task of the Integration Platform is storing, processing, and sharing electronic medical data, as well as the results gained from the quality of life questionnaires. Integrated care in Poland is one of the most important concepts related to the management and interoperability organization of healthcare systems. It should improve the quality of care and rationalize costs of medical services through coordination of care provision and cooperation between hospital care/primary care (outpatient clinic) and social care [3, 4]. To ensure a better quality of life of people aged 65+ with chronic diseases, health care system has to bear the economic burden of chronic diseases (that makes 46% of the global burden caused by all diseases) [5, 6, 7].

2. Mobile services process modeling for frail patients

Change of the current model of health care services for patients, users of primary health care (PHC) services, require the development of modified medical procedures and their acceptance by the ethics committees before applying them in the project. Acquired applications were built in order to support the current medical procedures with necessary modification and integration. Monopolistic aspirations of IT companies and reluctance to integrate with another product that is intended to cover the full functionality, was one of the problems of testing and integration. A business processes model was implemented to understand the new roles of the doctors, nurses, and call center service. It was very laborious and important stage of the project. Processes and communication with the central database, which is available for the project coordinator, required attention to elements related to the protection of personal data and semantic interoperability and technological formats of the data transmitted from all project partners from EU countries.

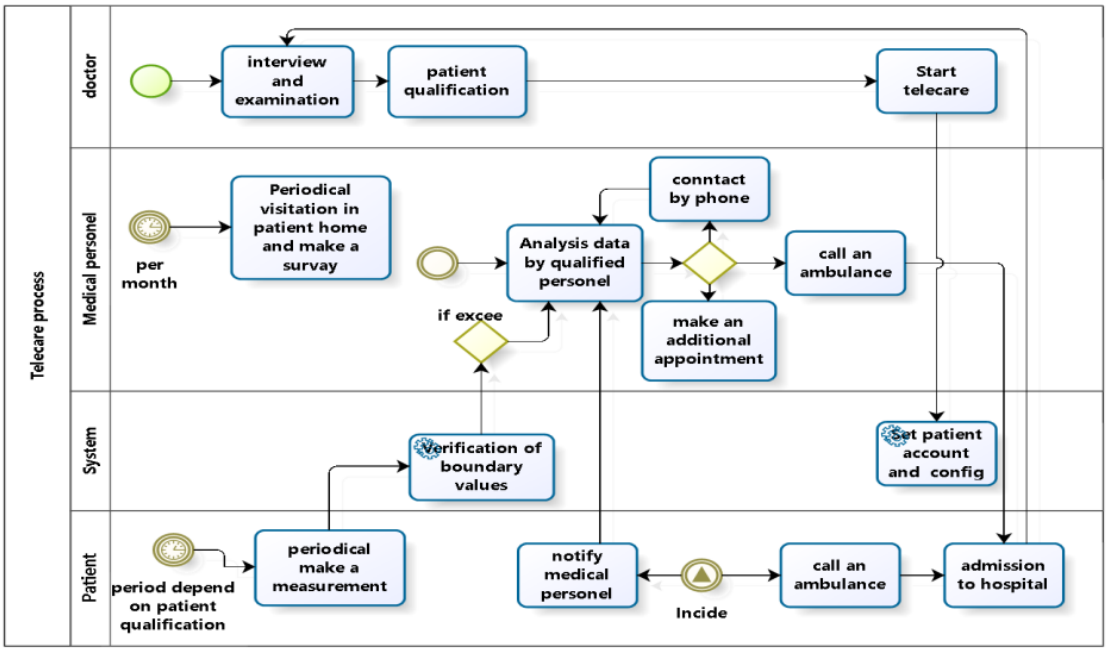

Fig. 1. Mobile health care process

The processes depicted in figures 1 and 2 show that some tasks of doctor or nurse are taken by information system. For example, the control of monitored measurements of critical parameters with measuring devices by the mobile communication platform. The role of the support person, who provides support for patients in the call center, should be noted as well.

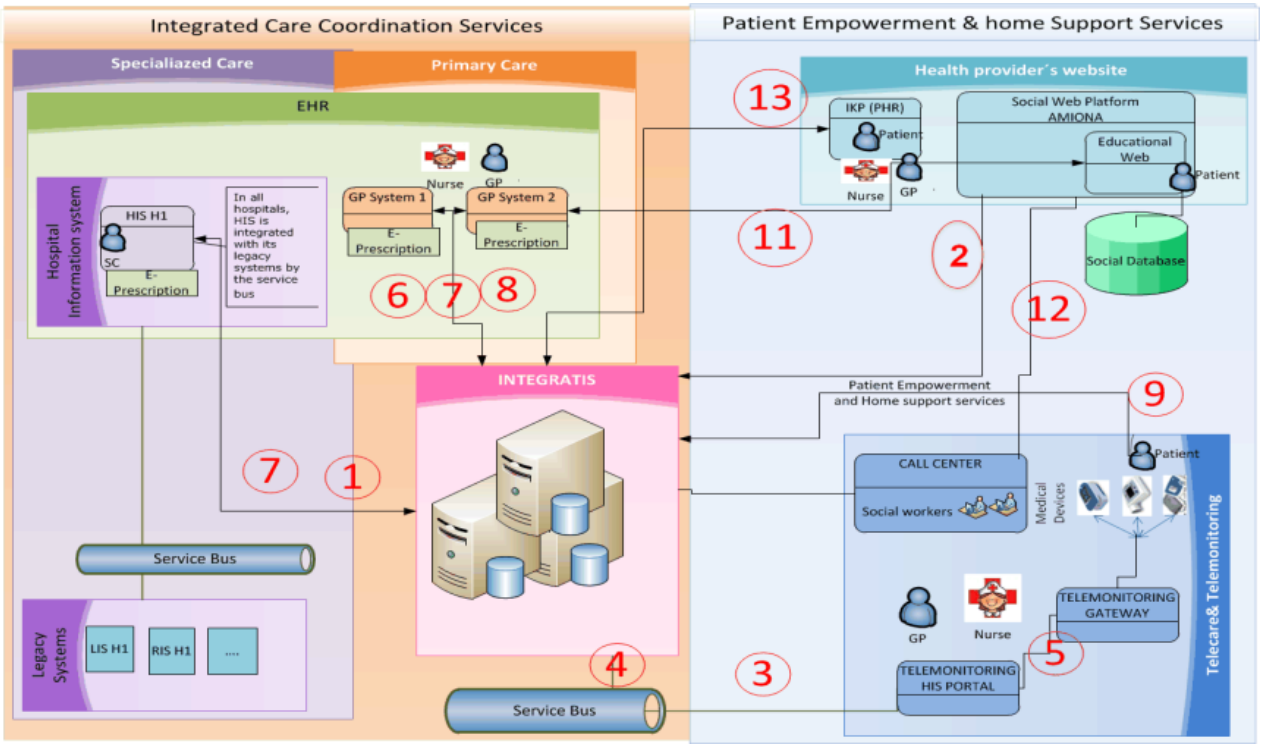

Fig. 2. CareWell ICT Architecture in Lower Silesia

The platform presented in figure 2 has to provide an interoperability between different IT systems that are used in the primary and secondary care. It should enable various care practitioners and patients to share information within new functionalities:

1. Registration of patient's home care and telemedicine referrals. This is the first task in the LSV

Telecare platform (LSV − Lower Silesia Voivodship).
2. Logged-in user's access to the Information-Education Portal and to the Integration Platform.
3. Patients Registry Update Service in Hospital Information System (HIS) through Integration Platform.
4. Service of transferring research results by HIS Patient Portal to Integration Platform.
5. Registration of the performed patient's results in HIS Portal.
6. GPs access to Electronic Health Record (EHR) and the tasks supporting LSV Telecare procedure.
7. Nurses access to EHR, and their tasks supporting LSV Telecare procedure.
8. Patients access to their own EHR and their tasks supporting the process of LSV Telecare procedure.
9. Implementation of developed services at the country level, like e-Prescription within LSV Telecare procedure.
10. Call Centre staff access to their own tasks supporting LSV Telecare procedure − receiving an e-mail and SMS alerts.
11. Doctor, nurse and patient's access to the Education-Information Portal.
12. Call Centre staff's access to the Education-Information Portal.

3. Organization and communication of the IT platform

At the stage of preparing implementation the requirements, which were then transferred into the BPM process model, have been identified. The Integration Platform is mainly supposed to implement telecare in accordance with the modelled procedures and to enable an adequate response in any situation. It was done using the Application Programming Interface (API) to give applications access to connect and essentially communicate with other programs. Another task of the integration platform is storing, processing and sharing electronic medical data as well as the results of quality of life questionnaires. Key aspects in the design of a modern system of telecare are the integration of technological solutions and the existing information systems, as well as the applicable procedures of patient care with mobile technologies in telecare. These issues are the subject of numerous publications on computer systems and their clinical effects [3, 4]. These actions should show the benefits and how to teach the end user (that is a patient) and how to operate mobile measuring devices at home. Therefore, the system design involves the integration of three subsystems:

- Education-Information Platform (Social)
- Integration Platform (Service Buss)
- Monitoring Platform

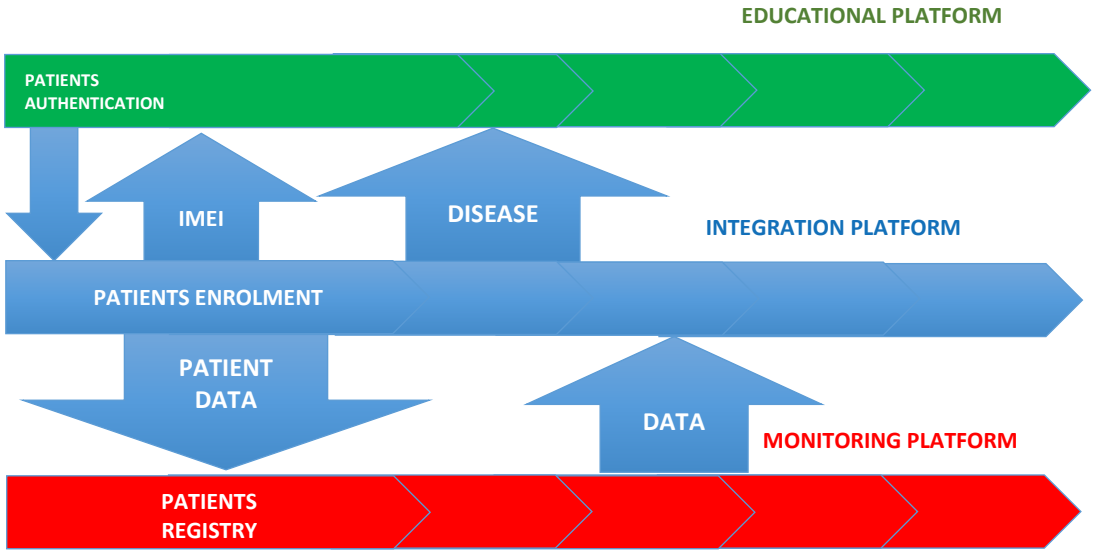

Figure 3. Multi-level integration of implemented platforms

Each of the above mentioned systems functionally meets the requirements of the identified key aspects. The Monitoring Platform is responsible for operation of measurement devices. It is based on mobile devices for telemonitoring of stable and unstable outpatients. A call center worker monitors the patients' medical parameters and contacts a doctor or nurse, when a patient's health status is exacerbated. Next, the doctors or nurses evaluate the patient's medical parameters, determine the cause and act on the results. Patients can be reached by the call center worker via an Android video application. The multilevel integration is depicted in figure 3

The most important issue is the reliability of the measurements in the context of user authentication. It is unacceptable to assign mistaken measurements to a patient. On the one hand, a suitable authentication and data security, and on the other hand a greater ease of use and reliability. To meet these requirements it is necessary to take these constraints into account at the stage of designing of a subsystem, which is supposed to manage multiple tasks.

The next subsystem is the Integration Platform, which main task is to integrate all the subsystems and enable their use to cover specific requirements. Requirements are identified at the stage of preparation for implementation, then they are transferred into the BPM process model. The most important task, as well as the most difficult task to be completed by mid-subsystem, is to educate patients that the use of telecare increases their safety and a quality of life. An Educational Platform can be accessed by patients through authentication via smartphone application. The information on the platform covers educational material about chronic conditions to help patients manage their situation better, as well as a specific information.

4. Material and method

The main CareWell Project goal was the integration of three platforms existing independently on the IT market, as well as testing and collecting of data to be analyzed in real time. Next, the work in the project design was based on modeling and implementation of telecare procedures. The suppliers of technical solutions were selected for integration and implementation. This work was followed by training of medical staff − doctors and nurses. Individual technical support for patients included a set of mobile phones − smartphones L65 LG (LG-D280n) for each patient. The characteristics of the entire examined group is depicted in table 1. All groups of patients were equipped with mobile devices accordingly to the health status to be monitored (see tab. 2):

- Patients in A group (diabetes) have received the Diabetic set including glucometer – ProfiLine Blutzucker Messsystem – 20 pcs.
- Patients in B group called COLD (with Chronic Obstructive Lung Disease) have received a set including peak flow meter (Astma-1 Vitalograph) and pulse oximeter (PC-60NW) −5 pcs.
- Patients in C group (hypertension) have received blood pressure monitor (Senior Line BT model TD-3128) – 15 pcs.
- Patients in D group (chronic heart failure, CHF) have received pulse oximeter (PC-60NW) and a weight scales −10 pcs.

The criteria for including patients into the follow-up observation at the age 65−85 were following: combination of notless than 2types of diseases: hypertension (ICDI10), diabetes (ICDE11), chronic obstructive pulmonary disease (ICD J44), heart failure (ICDI50). Another required condition was to obtain at least 60 points according to the Barthel scale.

Qualification took place pursuant to the analysis of hospital summary report. Patients qualified for observation, were divided into two groups. The target size of both groups is 50 people. Persons covered by telemonitoring, who were provided with measuring devices depending on the disease, were in the Group 1. Patients not covered by telemonitoring and who received no measuring devices were in Group2.

The total number of patients (100) has been recruited for LSV Pilot site; 50 patients have been assigned to the intervention group, and 50 to the control group. Average age of patients was 74.49 years, in the control group patients were a bit older, but without statistics significance. According to gender distribution, there are differences between groups: 64% females in the intervention group and 38% in the control group. The selection of the control group (control) and intervention group with equipment (intervention) was not conducted with the right the proportions of men/women (the proportions are

reversed). It was random selection. This is why the average age in the control group is higher by almost 2 years. However, it is not statistically significant. The enrolment into both groups seems to be appropriate.

More surprising is the over-representation in the control group of patients with congestive heart failure − 52% comparing to 4% in the intervention group (with devices), similarly with dementia (but in reverse proportion). There is a small difference in mobile and PC use between groups and the low percentage of subjects familiar with the mobile phone (36%) and high with PCs (92%).

Table1. Characteristics of patients enrolled into the project

Measurement	Total	Intervention	Control	p-value
Sample size (n)	*100*	*50*	*50*	
Age	74.49 (6.67)	73.76 (6.66)	75.22 (6.66)	**0.276**
Gender				**0.016**
Female	51 (51%)	32 (64%)	19 (38%)	
Male	49 (49%)	18 (36%)	31 (62%)	
Housing tenure				**0.362**
Owners	95 (96%)	49 (98%)	46 (93.9%)	
Renters	4 (4%)	1 (2%)	3 (6.1%)	
People older than 18 living in household, median (IQR)	1 (1.2)	2 (1.3)	1 (1.2)	**0.139**
Mobile use (Yes)	36 (36%)	22 (44%)	14 (28%)	**0.145**
PC use (Yes)	92 (92%)	48 (96%)	44 (88%)	**0.269**
Height (cm)	166.41 (9.07)	167.84 (8.68)	164.98 (9.31)	**0.115**
Body mass (kg)	80.79 (12.51)	81.94 (12.58)	79.64 (12.47)	**0.361**
Body Mass Index (BMI)	29.2 (4.24)	29.18 (4.72)	29.23 (3.75)	**0.955**
Heart rate (bpm)	74.11 (6.57)	74.52 (3.36)	73.7 (8.69)	**0.536**
Systolic blood pressure (mmHg)	130.05 (7.86)	127.7 (7.12)	132.4 (7.93)	**0.002**
Diastolic blood pressure (mmHg)	79.95 (5.5)	79.62 (4.34)	80.28 (6.48)	**0.551**
Oxygen saturation (%)	94.4 (2.42)	93.52 (1.94)	95.28 (2.54)	**<0.001**
Blood glucose (mg/dl)	120.75 (45.89)	118.96 (37.62)	122.54 (53.24)	**0.699**
Primary disease				
Primary disease CHF	23 (23%)	10 (20%)	13 (26%)	**0.635**
Primary disease COLD	8 (8%)	5 (10%)	3 (6%)	**0.715**
Primary disease DIABETES	38 (38%)	20 (40%)	18 (36%)	**0.837**

Results comparable between both groups which are very prevalent for DIABETES primary disease, both for the intervention and the control group, and are prevalent for Congestive Heart Failure CHF secondary disease.

Table 2. Number of measurements

Disease	Number of patients	Mobile Devices	Measurements		
			Daily	Weekly*	Alarms*
Diabetes	20	Glucometer	~40	260	~28
COLD	5	Peak flow meter Pulse oxymeter	15	105	~7
Hypertension	15	Bloodpressure monitor	30	210	~21
Heart Failure	10	Pulse oxymeter Weight scales	30	210	~14

* Weekly measurements

Another significant characteristic of participants is their level of functional dependence, measured by Barthel Index. In this case, there are no differences between the intervention and the control group and all present a median of 100 indicating autonomy. According to the baseline mental health, both groups present mean values corresponding to normality.

The system has registered more than 3000 alarms that were handled by the call center. With regards to the measurements and data collection, all the data of the patient group with equipment showed the number of alarms generated per week in the amount of 10% in each group.

5. Conclusions

Operational phases of CareWell system of integrated platforms, were presented. In the period of 10 months more than 35 000 measurements values were sent to the database and the system has registered more than 3000 alarms. In the initial stage, most of them were caused by the problem how to use the platform and were related to errors in performing measurements or improper way of mobile phone use by patients (phone was not switched on or the battery was low). Most of them were solved by a phone call – altogether 1500 calls (call center to patients and vice versa). Less than 15% of incomplete measurements required the intervention at patient's home. Currently, the system has entered a phase of stabilization and some of the earlier organizational and procedural problems have been completely eliminated. This phase of the project involved patients aged 65−85 years with at least 2 chronic diseases; including hypertension (ICD I10), diabetes (ICD E11), chronic obstructive pulmonary disease (ICD J44) or chronic heart failure (ICD J50). 100 patients were qualified on the basis of medical history (last stay in hospital) and were divided in two groups, as described above. The measurements results were transmitted automatically via mobile phone network to LSV Telecare (Lower Silesia Voivodship Telecare) system. It was shown that the integrated telecare gives more benefits to the patients. Social functionality provides an easy access to their case record (medical history of the disease) and the possibility of being properly.

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