Decision Support Systems and Education
J. Mantas et al. (Eds.)

doi:10.3233/978-1-61499-921-8-160

A Concept for Improving Cross-Sector Care by a Mobile Patient Navigator App

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Abstract. Hip and knee joint prosthetic implants are common surgical interventions in Switzerland, as well as in other countries. Different care providers are involved in the care process which constitutes a potential risk of inefficiency and communication deficits. A patient can get lost on his cross-sectoral clinical pathway, miss appointments or underestimate the relevance of certain control visits or examinations. To address this, we introduce a concept for a mobile application that guides patients along the cross-sectoral clinical pathway. The information on appointments is consistently retrieved from information systems at the care provider's side. This facilitates the coordination of activities and appointments not only for the patient, but also for the care providers. The aim is to promote the patients' autonomy, to support their management of appointments, to increase the understanding for their clinical condition and to improve their adherence to the prescribed measures – all of which lead to an improved outcome. Another aim is to increase patient satisfaction in terms of adequate information and quality of treatment. The advantages and disadvantages of the concept will be discussed. goes here.

Keywords. Integrated care, Patient empowerment, Mobile application, eHealth

1. Introduction

Endoprosthetic hip surgery (hip TEP) is an effective therapy for patients with significant, permanently impaired joint function due to destruction and pain that cannot be treated in any other way, as well as for the treatment of fractures near the joint. The various joint replacement procedures are designed to restore good functionality, resilience and quality of life. Switzerland had, compared to OECD countries and the USA, the highest number of hip joint replacements with 292 of 100,000 inhabitants receiving a new hip in 2012 [1]. Due to the fact that patients in need for a hip TEP are mostly elderly and suffer from additional diseases such as hypertension, diabetes etc., they require optimal preparation for this planned (elective) intervention. This prompts additional consultations in internal medicine, anesthesia and other specialties dealing with many actors and new information is constantly conveyed. The process may involve several outpatient appointments with medical specialists and additional examinations; the surgery in a hospital, followed by a rehabilitation phase in a rehabilitation center and later on outpatient follow-up, physiotherapy etc. Thus, the patient can easily be overwhelmed with the management of his appointments. He or she is risking to miss appointments or to forget to bring relevant

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information to the next encounter. There is a high risk for inefficiencies, communication deficits and information loss due to the distributed care delivery. In the context of hip and knee endoprosthetic surgery, there is still a huge potential for optimization [1].

However, so far, there is only limited support for the patient to address the above mentioned issues. Some publications reported the use of mobile apps for monitoring the quality of recovery in post-operative patients at home [2]. TEP App [3] is a mobile app for hip TEP patients which provides information about the disease and treatment process. The app lists information on the current state in the treatment path and supplies information for physiotherapy exercises. The patient can create goals for his rehabilitation and keeps a patient diary. However, this application does not support the actual time and appointment management and no data exchange with physicians or care team exists. TEP app does not support dynamic or patient specific handling of appointments and information.

The Mayo Clinic app [4] supports a patient to make appointments with this particular hospital and provides access to laboratory results or radiology images. But the patient can only inquire for appointments using the app. There is no dynamic appointment handling or seamless integration with health care provider's information systems. This however would be desirable during inpatient treatment where nurses or other staff members arrange appointments for the patient e.g. with the physiotherapist or radiologist.

SeamlessMD [5] provides a cloud-based platform for hospitals to educate, engage and monitor patients before surgery. The platform provides patients with evidence-based education, timely reminders, video education, progress tracking tools and feedback for self-management. For health care providers and administrator real-time analytics exist, which allow to monitor patients remotely, derive insights about the patient experience and measure organizational performance.

In contrast to this related work, we introduce a concept where a mobile patient navigator application "PathApp" is integrated with physician and hospital information systems to continuously synchronize appointment data. Its aim is to enable the patient to keep track of the required diagnostic and therapeutic procedures at any time in outpatient and inpatient care, rehabilitation and at home. In addition, patient-specific information for each process steps is available. Checklists, e.g. prior to hospital admission, remind him or her what to do.

2. Material and Methods

This work is embedded in the "Hospital of the Future Live" project (SdZL), involving 25 stakeholders including 16 companies and six hospitals in order to develop IT solutions for future eHealth optimized health care processes [6]. Within SdZl an in-depth analysis has been performed to determine the required medical activities for a fictional elderly and multi-morbid patient requiring hip surgery and implantation of a total endoprosthesis (TEP) for advanced arthrosis of the hip joint. These activities have been examined for their potential for improvement with information and communication technology, deriving more than 28 student projects to realize IT-prototypes.

In this work, we analyzed interfaces of existing physician and hospital information systems regarding their ability to synchronize appointment data directly with another application. We identified challenges and open issues that need to be addressed before a completely integrated PathApp can be realized. Currently, the PathApp concept is implemented as a demonstrator in the medical informatics laboratory of the Bern

University of Applied Sciences. This laboratory consists of a simulated environment of the Swiss national health care system comprising multiple institutions (e.g. doctor's surgery, hospital with theater, intensive care unit etc.) and is equipped with the relevant information systems for inpatient and outpatient care.

The presented PathApp architectural approach has been derived from three potential architecture models considering an optimized solution regarding: 1) Development cost, 2) Dependencies on third parties, 3) Update process, 4) Adaptability. Each architecture model was analyzed and rated with respect to these categories. The architecture with the best overall rating was selected.

3. Results

3.1. Requirements

The PathApp is supposed to guide the patient through his or her treatment path. Requirements include a personal appointment organizer, reminder function, checklist and information provision as well as direct communication with the healthcare provider via app. The current priority is the architecture for the organizer element of the application. The organizer functions include the calendar providing dates and information on appointments and the reminder function for due dates. As an outpatient, he or she will arrange the appointments in direct contact with his or her care provider, e.g. the GP. As an inpatient, nurses, physicians and other healthcare providers will manage the patient's appointments from outside. The PathApp is designed to deal with both situations and to keep the patient current even during his hospital episodes. By design, the respective healthcare provider is the master of his or his institutions calendar. Thus, patient appointment requests have always to be confirmed by the healthcare provider. Similar to the concept of the patient board within a lean hospital [7], the relevant data should be visualized in an intuitive manner.

3.2. Concept

The PathApp front-end visualizes appointments as a timeline with upcoming dates with health care providers. By clicking on a data entry, details are displayed. Appointment scheduling is normally realized using the information systems of the care provider. To ensure a consistent workflow and in order to avoid double data entry, the appointment data for the PathApp must be synchronized with the respective information systems of the different care providers. A particular challenge is that there is a variety of information systems used by different institutions. To address this difficulty, the proposed system architecture comprises three layers (Figure 1): customized interfaces to the information systems, a centralized data storage and an interface to the front-end application PathApp. The task of this centralized data storage is to retrieve and synchronize the patient's appointment data with the different information systems through dedicated interfaces. A continuously running polling process retrieves the scheduling data from the respective information systems and stores it into the pre-structured central database. In case the connected information system are in future able to notify the PathApp on individual scheduled changes, polling would not be required. The interfaces can be installed on the PathApp server as independent modules. In order to manage several instances of the PathApp, a user management is required on the PathApp-Server. The communication

between the PathApp-Server and the PathApp itself is realized through a REST-API on top of the database of the central server.

In the current architectural concept, the centralized data storage contains only appointment data and no medical information such as examination results. This data can be later extended by standardized patient information on the scheduled appointment or checklists to ensure that the patient brings all relevant information to the appointment or that he or she meets certain conditions (e.g. patient comes fasting to the appointment). The collected data is automatically converted to a unified format. The mobile application receives the unified data from the database and processes it. Through a user management, multiple instances of the application can access their user-specific data.

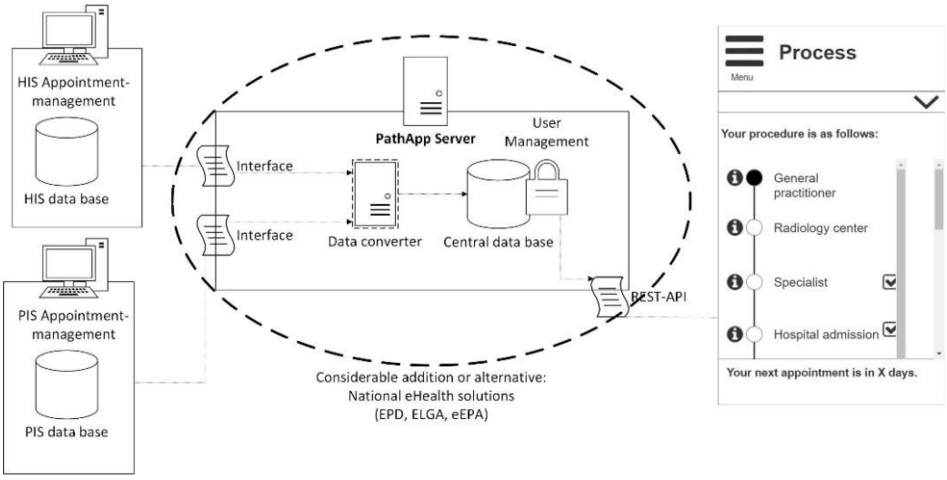

Figure 1. System architecture: The PathApp Server retrieves the data from different information systems through dedicated interfaces. The retrieved data is converted into the defined data structure of the database. Multiple PathApp instances can access this data through a dedicated interface on the PathApp Server. ational eHealth platforms could be considered in addition or even as alternative to the PathApp Server.

4. Discussion

Digital mobile technology has the potential to fill the gap from discharge to first postoperative visit. However, experiences with these devices still need to be gained to see data on the impact of improved digital communication, readmissions, patient satisfaction and patient compliance [8]. The architectural concept of the PathApp simplifies the integration of further institutions by integrating their information systems through a corresponding modular interface. The PathApp frontend is not affected and can immediately work with the new calendar dates.

However, several challenges have been identified when drafting and implementing the architectural concept of the Path App. One challenge concerns the interfaces to the various physician and hospital information systems. Today, a consistently used standard for the exchange of appointment data among different inpatient and outpatient information systems could not be identified. For information systems within a hospital HL7 version 2.x is often used, but the appointment structures are usually self-designed.

Thus semantic interoperability is a task which must be incorporated into the respective interface. For systems used in ambulatory care such as physician information systems no broadly used standard could be identified at all. Thus, it remains difficult to integrate the entire range of information systems from the general practitioner to the rehabilitation clinic. Several of the examined clinical systems do not provide an interface for the exchange of appointment data at all, thus requiring direct data base access if permitted by the manufacturer. Overall, the communication with all the information system manufacturers is estimated to be very complex.

Another challenge is the cross institutional patient identification. In the current state of the concept, the patient identifier must be retrieved and stored for each connected information system. Ideally, this would be resolved by a cross-institutional master patient identification system (MPI). This issue is addressed in the various eHealth platforms which are currently implemented in different European countries such as the ELGA in Austria and the EPD in Switzerland. Therefore, those platforms should be considered as an addition to the described architectural concept. They will, however, only provide MPI data for registered patients with an electronic health record, thus scheduling would not be possible for all patients for a long time.

In addition, a clear data structure standard for cross-institutional appointment communication should be developed. Existing standards such as the HL7v2 SIU messages or the HL7 FHIR appointment resource can be considered as a basis for the development of such a standard. Ideally, the standard should also support additional personalized encounter information such as the previously mentioned checklist function for the patient. The complex synchronization of appointment cancellation and appointment rescheduling must be considered when developing the standard. Furthermore, several challenges are related to the visualization of the data for the patient. One of those is the viewpoint and time horizon change caused by the transition from outpatient to inpatient treatment, where the latter requires a day perspective. As a next step, we implement a PathApp prototype based on the presented architectural concept and will carry out a usability study to improve the front end appearance.

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