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Use Technology to Help Medical Staff Treat "New Health Problems" Arising Constantly

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Abstract. The development of medical science allows the treatment of more and more health problems that in the past were not a factor of consumption of health resources, because at that time medical science did not have protocols for their treatment. Health problems that are now treatable, hereafter referred as "new health problems", often affect large population groups and require increased consumption of health resources. It therefore becomes necessary to increase the number of staff providing health services (doctors, nurses, etc.) and other resources. This raises the question: is it feasible to manage the "new health problems" by the existing medical staff? If not, are there other solutions? Could technology help the existing Medical Staff to sufficiently manage the "new health problems"? We will examine a pilot system "Recording and visualizing of outpatient monitoring data with smart mobile phones", which seeks to ensure the competence of existing medical staff in the effective treatment of the ever-increasing volume of transplant patients.

Keywords. Digital transformation, Sustainable Health Care Systems

1. Introduction

According to [1] Healthcare providers are faced with growing pressures to provide high quality and effective healthcare services in the face of increased demand due to growing and aging populations. In their conclusions they mention that smart healthcare strategies have been identified as a solution to the challenges the healthcare sector is faced with. The mediators for smart healthcare strategies are Smart healthcare technology achievements. The term smart/modern healthcare technology [1] can include: mobile internet, Cloud Computing, big data, AI, smart biotechnology, etc. Smart biotechnology includes smart beds, smart monitors, smart wearable devices (e.g. biosensors, smart thermometers, smart connected inhalers, ECG and Blood pressure monitors), etc.

As of 2016, researchers [2] report that there is a progressive transition from aggressive therapies to oral prescriptions or less invasive techniques that are compatible with home care (e.g. oral chemotherapy, peritoneal dialysis and remote monitoring). These transitions facilitate a shift in care from acute settings. Many more treatments will be provided to patients, without hospital admission. Patients will recover at home with community support. The authors had envisioned a network of complex, interconnected

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health care services to be provided outside of hospitals, as well as systems for transferring people discharged from acute care to primary, home or elderly care. This reality requires a conceptual shift from the conventional focus on isolated episodes of care (ADTD) to an appreciation of the entire patient journey including primary health.

According to [3] "Recent developments in eHealth, digital transformation and remote data interchange, mobile communication, and medical technology" derive a new health services paradigm that emphasize to the transition from sporadic acute healthcare to continuous and comprehensive healthcare. This paradigm is further refined as "anytime and everywhere access to safe eHealth services".

Another review [4] studying the digital transformation of healthcare finds that digital technologies (such as telemedicine, electronic medical records, wearables and mobile health apps) have already started to revolutionize healthcare delivery. The potential consequences are improved patient outcomes and increased access to healthcare services. Of course, the adoption of these technologies is not without difficulties. They conclude that a "digital-first" approach to healthcare will make it easier for healthcare providers to prioritize preventive care, coordinate care across different groups and regions, and deliver convenient and personalized services for each patient.

In the context of the above-mentioned Transitions mediated with the mentioned new Technologies we are examining our basic question: Could technology help the existing Medical Staff to be sufficient to manage the "new health problems"? We do it with the help of a use case: "Recording and visualization of outpatient monitoring data – of kidney transplanted patients – with smart mobile phones".

In our knowledge, there are already other scientists, having similar to our concerns. Fatemeh Dinari et al. [5] seeks to identify the barriers, benefits, etc. of utilizing speech recognition in nursing reports. David Scheinker et al. [6] developed a tool that identifies patients of type 1 diabetes appropriate for contact with specialists, based on data from continuous glucose monitors. They reduced 43% the patients reviewed by specialists.

2. Methods and Technology

2.1. Problem description

Transplanted patients are obliged to undergo surveillance as the regulation of the immunosuppressive treatment they receive cannot be static. Follow-up is lifelong and its frequency is particularly dense in the first months, after transplantation. For this purpose, the transplanted patients must visit the few specialized hospitals in each follow-up cycle to carry out the prescribed laboratory tests and then, be examined by the specialized Doctors. The Doctors, based on laboratory results, physical examination of the patient and data measurements (blood pressure, fluid intake and urination volumes, temperature, defecations, etc.) recorded by the patients themselves between two visit cycles, decide on the adjustment of the immunosuppression as well as the regulation of other medicinal supplements. Continuous monitoring of transplant patients becomes even more complex as they are obliged to make emergency visits to the monitoring units at any emergency symptom (fever, chills, pain, shortness of breath, frequent headaches, vomiting, profuse diarrhea, recurrent malaise, swollen fingers and face, swollen legs, hematuria).

2.2. Data

The information/data that are needed for the surveillance and/or for the adjustment of medications come from various sources. Self (by patient) measured signs can be Temperature, Pressure and Pulses, Weight, Urine Volume and Fluid Intake. These can be measured daily or few times per month. Laboratory test results measured in each surveillance cycle can be creatinine, urea, potassium, hemoglobin, hematocrit, etc. Medical images (e.g. heart triplex, abdominal US) are also significant for the surveillance.

2.3. Legacy process and Technology enhanced System requirements

Because the data comes from different sources: laboratory tests, self-measured vital signs, clinical observations, and imaging modalities, they are not available in a uniform way and doctors must synthesize and evaluate them all together. A legacy process required standardized multi-column forms where physicians filled out a line for each patient follow-up cycle, recording the data from the different sources in the columns of the form. So, doctors could see the progress of the patient's health by comparing the lines of the forms. Such a legacy procedure runs the risk of underfilling and wasting the doctor's time. To resolve such issues, we need a solution to permit:

- Recording of data measurements by the patient himself with the help of his/hers smart phone, in order to be immediately available the physicians, in the following “Recording App”,
- Tabulated view of all data (laboratory results, self-measurements of patients, physician’s clinical observations, etc.) on the Doctor's computer or smart phone, in order to have available the legacy but well-known overall presentation method. In the following “Visualizing App” – Tabular format,
- Visualization of the data measurements (with charts or another augmented format) on the Doctor's computer. In the following “Visualizing App” – Charts.

In the digital transformation more information/data can be utilized:

- Daily comments (short text) that a patient can enter to remember a change in treatment or to inform the Doctor (communication channel with the Doctor),
- Comments for a period of days,
- Alerts that may be prescribed by the Physician and reach the receiving patient.

2.4. EAV and why

Regarding the representation of data, a simple relational schema, a naïve transport of the legacy multi-column paper form to a database table, could suffer from a great percent of empty cells. This is because not all laboratorial tests are performed in each surveillance cycle and measurements recorded by the patients themselves are recorded with different frequencies between different patients (based on the Physician’s instructions, e.g. blood pressure and pulses measurement can be once per week for patient A and every day for patient B). To resolve this issue, the Entity-Attribute-Value (EAV) [7, 8] is our selection. The EAV representation also permits dynamic database schema evolution [9].

2.5. Description of "Recording App" and Technical choices

We have built the "Recording App" with the Android Studio Hedgehog IDE, Java 17.0.7, Retrofit2 and OkHttp3 (for HTTP requests), FasterXML Jackson (JSON serialization / deserialization), MySQL database (hosted on a Spring Boot server – SBS) and RESTful API. The App permit the user (patient) to record the laboratorial results, the self-measured data, comments (daily or periods of days) and also to receive Alerts.

2.6. Description of "Visualizing App" and Technical choices

We have built the "Visualizing App" with the IntelliJ IDEA IDE, ReactJS JavaScript Library (frontend), Reactstrap (responsive and visually appealing UI elements), Chart.js charting library (visualizing medical data), RESTful API for Backend Connectivity (communication between the "Visualizing App" and the SBS). The App permit the user (doctor) to view data in tabular form (the legacy presentation), view data in visual form (mainly charts) with one or more series of data and to administer the patient profile.

3. Results

We have managed to build the applications according to the requirements specifications. The applications created were installed on potential users to test their simplicity and correctness of operation. These users were doctors, in order to have the knowledge needed to check the correctness of the operation. The conclusions are very encouraging. Users' opinion is that the "Recording App" is very simple and the data that the patients should enter are enough for the surveillance.

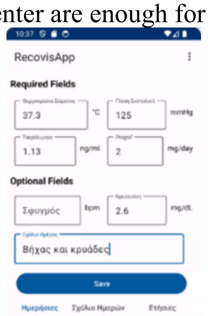

Figure 1. Daily data

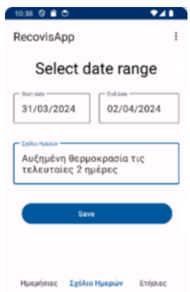

Figure 2. Comments

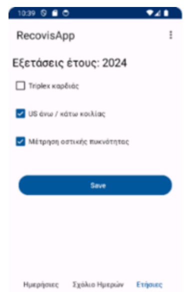

Figure 3. Yearly reminders

Figure 1 presents the "Recording App" during the insertions of data values required by his/hers profile in a day that he/she had exams and he/she got the results for tacrolimus (the level of an immunosuppressive active substance) in his/hers blood. Figure 2 presents the comments for a two-day period that the user enters in the "Recording App". Figure 3 represents the alarm (yearly reminders) tab of the "Recording App" for the same user.

Regarding the "Visualizing App" the users (doctors) were more demanding. They requested that the process of patient's profile administration (adjustment) should permit some couples of attributes to be indivisible. For example, they demanded when the patient's profile is augmented with one immunosuppressive medication (e.g. prograf), the system to automatically augment the profile with the corresponding active substance measured in blood (e.g. tacrolimus). Figure 4 presents one chart created by the "Visualizing App". The user (doctor) can add/remove attributes (fields) dynamically.

Figure 4. Chart of creatinine and potassium for one month period

4. Discussion and Conclusions

The prototype system has been presented to the authorities of a big University Hospital, existing in Athens. Based on the live presentations, they have concluded that the technology we have built permit to the existing Medical Staff to be sufficient to manage the continuously increasing demands for the surveillance of kidney transplanted patients. Recently (July 2024), we got the written permission from the Scientific Council of the University Hospital to apply the system. The system is to be put into pilot operation in early October 2024.

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