Database Reengineering of the Registry of Tuberculosis

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***Abstract*—Registry of tuberculosis is intended to record the clinical path of the treatment and for reporting statistics to the Institute of Public Health regarding the patients with tuberculosis. It has been entrusted to the University Clinic of Pulmonary and Allergic Diseases Golnik. To improve the efficiency of work a proposal of changes has been made to the database model of the registry of tuberculosis. The chosen methodology of information system development is based on the principle of the prototype modeling. It includes all necessary steps from the inventory of the work processes, collection of the maximum data set, development of the entity relational scheme, graphical user interface, risk analysis and logical access control. The proposed approach will not only increase the efficiency in the process view of organization and informatics but also reduce costs and make it more user friendly.**

Keywords- tuberculosis; register; clinical path; database; computer solutions

I. INTRODUCTION

Tuberculosis (contagious airborne disease caused by *Mycobacterium tuberculosis*) is still one of the leading causes of death for adults [1]. TB (Tuberculosis) causes 49 new cases and kills 7 people every hour in the EU alone [1]. Escalating HIV infection as well as negligence in TB control have caused an increase in TB incidence over the last decade in both developing and developed countries [1,13]. Moreover, several other factors such as homelessness, poverty, lack of infrastructure in public health, and inadequate access to health services have played an important role in worsening the situation. The management aspect of the TB control is one of the most important issues to consider in the prevention of TB infection, in particular, in urban setting. Management in terms of surveillance of tuberculosis aims to provide information to local teams to drive control efforts and, nationally, to inform policy. It is through surveillance that the general trends in cases can be determined.

The register of tuberculosis (RTB) records the course of treatment of patients with tuberculosis at a national level [6]. The data collection process of the tuberculosis treatment is recorded manually and is therefore quite time consuming. The aim of the proposed solution is to improve the process and design a new database, which would no longer require manual data entry through paper forms. It would provide direct data collection through e-forms. This would contribute to the promptness of the RTB, reduce possibility of errors in data entry and provide greater patient privacy. The following contribution shows systematic steps that were necessary to design the database model, graphical user interface and data access control.

This paper shows to show systematic steps that were necessary to design the database model, graphical user interface and data access control of Database Reengineering of the Registry of Tuberculosis. The first two sections of this paper provide the backdrop for understanding the nessety of Reengineering of the Registry of Tuberculosis and importance of the tuberculosis distribution, its influence

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on healthcare system and society. Section III reveals working methods used for constuction of new database, while Section IV illustrates how a prototype solution was developed.

II. AIM AND PURPOSE

With the proposed solution we aim to renew the RTB database by capturing the processes in e-form. The program is designed to be used throughout Slovenia, with the Golnik Hospital acting as the administrator of the RTB. The proposed solution assures interoperability with any system, i.e. for home care and system "computer beside the bed". Medical staff can enter data into the system directly at the site of treatment, using personal digital assistants (PDAs). Although this program is in a prototype stage new database and PDAs approach plays an important role in ensuring that high quality data can be quickly and reliably collected from numbers of patients who are distributed over different geographic areas in Slovenia. The proposed solution will allow different hospitals or individuals that need to record data of tuberculosis in dispersed locations to be able electronically capture data at the point of collection.

As this project is in a prototype form and was not yet implemented, we can not measure its true potential and benefits but, as shown within developed countries, personal digital assistants (PDAs) have promise as a new technology that can increase the quality and efficiency of data collection [14]. This study suggests that the design and implementation of the PDA intervention play a key role in a system's success.

Our research can be compared with the research taken in Peru by Joaquin et al. [15], where they implemented PDA approach for gathering data on multidrug resistant tuberculosis (MDR-TB) patients. They found that implementing information solution with PDAs approach decrease processing times, frequency of errors (as there is no transcription from paper based form to electronic one) and substantial reduction in the delays from collection to entry of laboratory results. Also it reduces workload for those involved in data collection and processing.

To better understand the importance of the new database and PDA approach we must look at simple case that is taken daily at RTB. Patients with latent form of tuberculosis are required to submit a monthly sputum sample at local health center or hospital. The sputum sample and smear result are then sent to the Golnik Hospital. The laboratory monitoring process begins with a smear microscopy test. Timeliness and accuracy of reporting laboratory results for these samples are essential to determine if a patient is responding to treatment and, if not, to alert physicians to the possible need for medication changes. In each health center the team records the smear test result on a paper form and in each regional laboratory the team records both the culture result and the smear result sent by the health center on a similar paper form. These forms are then sent to RTB where the culture and smear results are verified and retyped into the information system that collects data. The major disadvantages of this paper-based method are the delays in processing and entering laboratory results and data quality issues stemming from multiple opportunities for transcription errors.

To avoid problems discussed above, the proposed solutions are integrated in the existing hospital information system. This way, later transcriptions of data become unnecessary, what reduces the possibility of transactional errors and assures data integrity. Furthermore, with the proposed solution we can avoid the paper records and therefore lower the storage costs and times for processing of patients' data [4], while significantly improving the quality of the whole process [1]. A user-friendly web application enables users to add and delete data records about patients anywhere and at anytime.

Our proposed solution can be compared with ETR.Net (The electronic Tuberculosis Register) which is an electronic tuberculosis register designed for TB/HIV surveillance, program monitoring and evaluation. The system consists of a database which is accessed by the user via the software interface, custom developed for the Microsoft Windows environment. Its main implementations are in East African countries like Botswana, Guatemala, and Mozambique. It is a stand alone windows application there fore those not allowed any connection with clinical information system neither can be accessed trough internet.

III. WORKING METHODS

The construction method is based on the prototype modeling [3, 7]. Through interviews with the healthcare teams we have obtained the framework for functionality requirements. Critical analysis of the existing processes for data inputs and their processing provided insights regarding the existing ways of working with the registry exposed the requirements and the users' wishes. Based on the results of the current situation analysis, we constructed a prototype data model (ER diagram) which forms the basis for the construction of all required functionalities. We developed a graphical user interface with logical access control to enter, edit, view and analyse data about treatment of tuberculosis which can connect the web application and database registry.

IV. DEVELOPMENT OF A PROTOTYPE SOLUTION

A. Current Situation Analysis

The analysis of the current situation included the inventory process, paper documents and forms that support these processes substantially. In accordance with the analysis we defined five main processes as shown in Figure 1: A1 - The medical examination of the patient, A2 – Lab testing, A3 - Notification of tuberculosis, A4 – Medical treatment of tuberculosis, A5 – Final reports.

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B. Data Model

The analysis of the current situation allowed us to obtain the information that is important for understanding the contents of the work processes. With the maximum set of data we were able to devise an entity relational model for RTB. The entity relational model is made in IDEF1X notation [11], which makes the informational structure of the applications easier. Through normalization and 5th normal form we created 21 entities which are related and form a complete data model for RTB as shown in Figure 2.

C. Graphical User Interface

In order to access and display data and information, it was necessary to make an integrated graphical user interface which provides a graphical look and navigation pages. The graphic interface is designed with the CSS technology which stands for Cascading Style Sheet [5]. Figure 3 shows the design of the master websites and its tabs.

Users of the RTB web application are divided into three groups: doctors, administrative staff of the RTB and select laboratories.

Each of the intended users has a personal account, username and password. This is then reported to the system via the login page. The web application window displays data, links and information adjusted to each user individually. The adjustments are made in terms of links, options and levels of access as well as rights for modifying, deleting or adding new information or data. The two groups, namely doctors and administrative staff, have access to the RTB through the patient page shown in Figure 4.

D. Ensuring Data Security

Due to the data sensitivity, it is important to ensure adequate protection against intrusion attempts or deliberate disclosure of data. The critical risk analysis showed that despite the changes and additional security modifications, there are still certain external security risks. To ensure that the access is restricted, we added the logical access control to the RTB web applications.

This includes the set up of the systematic logical access control and the appropriate use of various tools, such as the firewall, intrusion prevention systems and intrusion detection systems [2, 8] to control access to the RTB database from an external network. To establish a logical access control it is necessary to distinguish between the subjects and the objects of the Golnik Hospital's own information system KOPA. A subject represents an entity that can perform an activity within the information system (physician, administrator, laboratory), while an object represents an entity of information system that the subjects are accessing. The access should be monitored.

Logical access control is divided into means of identification, authentication, authorization and logging [10]. This way the safety of data entry is ensured, the access of unauthorized persons is denied, and unauthorized disclosure of patient's data is prevented.

V. CONCLUSION

The proposed solution includes a proposal for reengineering of the registry database for tuberculosis at the Golnik Hospital. For this purpose we designed a database model that can be realized in any relational DBMS (DataBase Management System) such as Oracle, MySQL, DB2 and others. This enables the independence of the DBMS used, faster performance, and flexibility [7]. The proposed solution is interoperable with the other hospital information systems and programmed for exchanging data via graphical user interface or database. In the future it is crucial to continuously improve data access control at both organizational and application levels. The solution will help the RTB to become more efficient in terms of data integrity and price-performance as well as more user-friendly in terms of efficient data entry and anyplace/anytime access. The proposed solution closely follows the ideas of eHealth [12]. As such it can serve as an example of good practice for other health institutions in Slovenia and across Europe.

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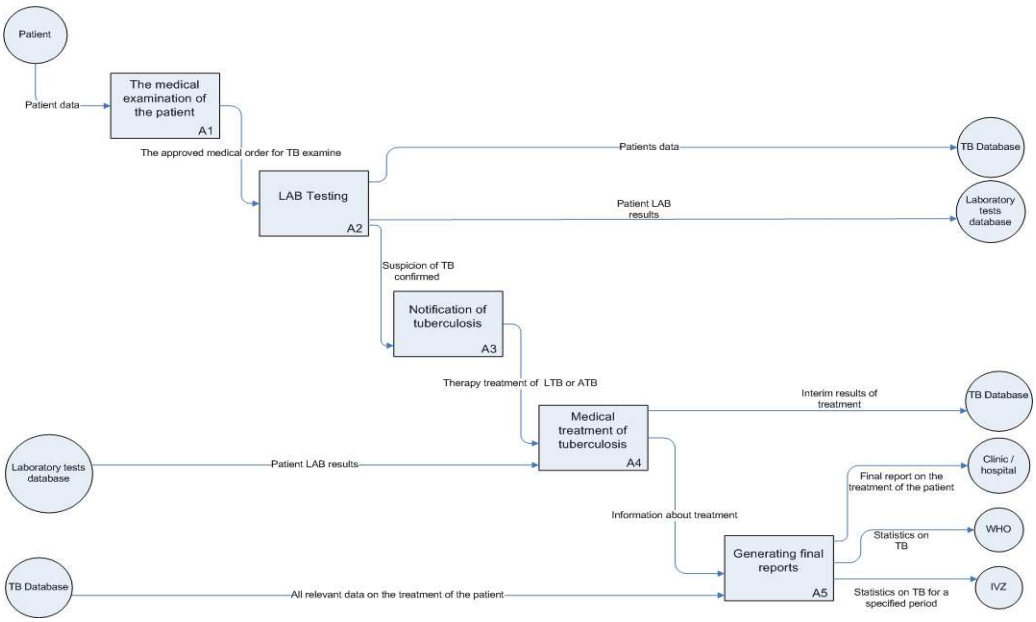

Figure 1. The treatment process in the frame of RTB.

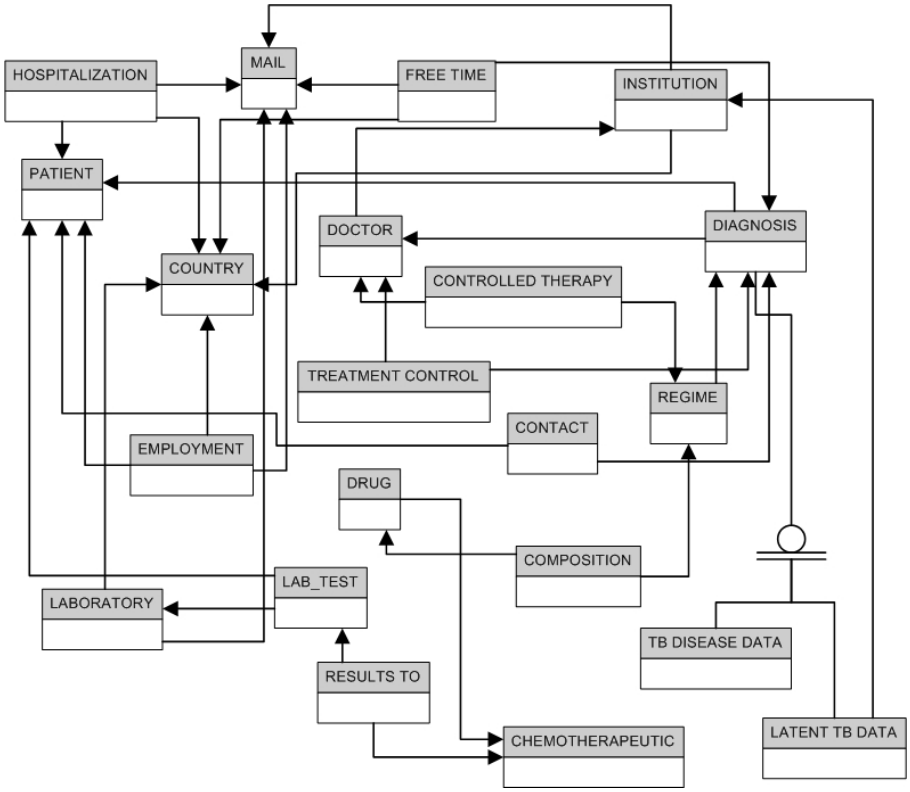

Figure 2. Entity-relational model of the RTB's database.

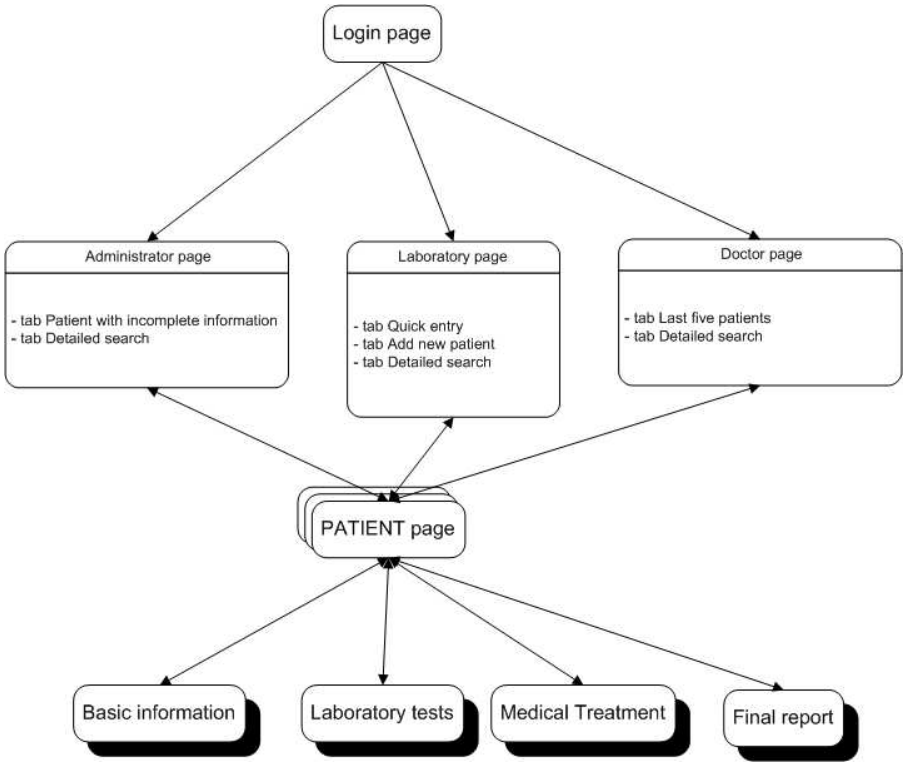

Figure 3. Site map of the RTB.

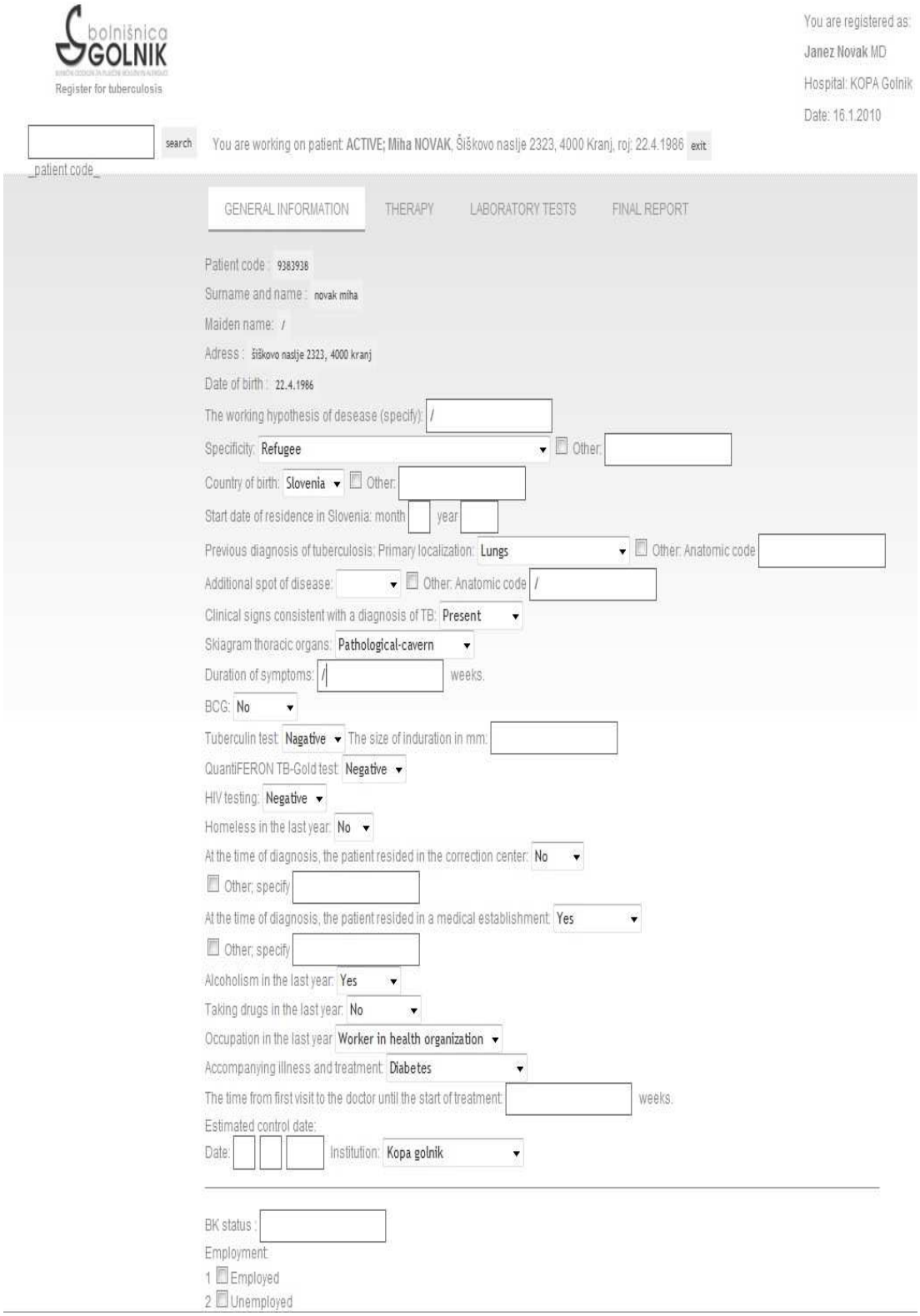

Figure 4. Patient data entry form taken from the RTB.

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