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**Project report**

**“Kids EHR”**

**Live demo:** [**http://prazdnik.kg/ehr**](http://prazdnik.kg/ehr)

Module HI-B-3: Information Systems in Health Care

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# **Introduction**

The main goal of this project is to create a EHR system for a kindergarten to manage children medical data and vaccinations. The system should contain general information about children as well as information about their health status and vaccinations received (viral hepatitis and COVID-19). The system must be easy to handle, having intuitive web-interface to manage EHRs and include general information about the organization.

Collecting and providing access to the latest EHR information of kindergarten members has a high importance during pandemic time. The system will help authorized persons, such as controlling bodies (ministry of health officials and other authorities) to monitor the vaccination status of children. On the other side parents will be able to see the latest information to decide whether they can send their children to the kindergarten.

## **Electronic Health Record**

Electronic health record (EHR) as defined by WHO, represents “*a longitudinal health record with entries by healthcare practitioners in multiple sites where care is provided*”. EHR definitions can vary in different countries depending of the healthcare system, legal environment and other factors. In the USA it is defined as: “*all information contained in a traditional health record including a patient’s health profile, behavioral and environmental information. As well as content the EHR also includes the dimension of time, which allows for the inclusion of information across multiple episodes and providers, which will ultimately evolve into a lifetime record*” [1].

As a rule, any electronic health record must:

• include personal health information of an individual.

• be entered and accessed electronically by healthcare professionals during the whole life of a patient

• cover all ambulatory care settings at which the patient receives healthcare services.

In order to increase the quality of healthcare, more countries implement the approach of keeping long-term EHR, when all healthcare services given to a person during the whole life in various institutions by different practitioners are being kept in a single record. It allows a more flexible healthcare experience for patients as they can easily change healthcare practitioners from different institutions.

EHRs keeping process requires an information system that captures all the information related to a healthcare service (time, place, diagnosis, procedures, tests result etc.) over an indefinitely long period of time. All the healthcare information must always be easily managed and accessible from different locations to be used by practitioners at any stage or level of healthcare process.

## **EHR vs. EMR**

Electronic Medical Record (EMR) and Electronic Health Record (EHR) both represent digital records of a person’s medical information. Even though they have common features and often used in the same context, they still represent different notions. While an **EMR** is a sort of ***local medical card***, containing medical and treatment history ***from one practice*** (in digital form), **EHR** stores ***records from multiple practitioners***. Therefore, EHR represents a more global view of a patient's health status, including demographics, procedures, test results, medical history, history of present illness (HPI), and medications.

The main benefits of EHR are:

* Availability in any healthcare institution, wherever the patient goes
* Containing a wider range of information about patient, that could help to improve healthcare outcomes.
* Compliance with standards for incentive programs administered by the Centers for Medicare & Medicaid Services. [2]

Thus, even though both EMRs and EHRs serve the same purpose of storing healthcare information in a digital form, EHR is more flexible and global solution.

## **History of EHR development**

The first EHRs appeared in the 1960s. The Mayo Clinic in Rochester, Minnesota was one of the first major health systems to adopt an EHR. By 1965, approximately 73 hospitals and clinical information projects and 28 projects for the storage and retrieval of medical documents and other clinical information were underway, according to HIMSS. In that period EHRs systems were very expensive and could be implemented by biggest hospitals in partnership with government In the beginning the system were used for billing and scheduling only. [3].

Later in 60s new “problem-oriented” medical records emerged, providing more effective communication and coordination among healthcare practitioners involved in the treatment process. Doctors recorded a patient’s diagnosis and the treatment they provided. As EHRs became more affordable for clinics in the 1980s, and they were extended with fields that could be filled in with mor detailed information about the patient, history of illnesses, medical diagnosis, treatment plan.

With the development of EHR systems, the problem of standardization emerged. There was a need to make various systems interoperable, and to provide effective exchange of information between a growing number of medical institutions, to effectively coordinate healthcare of patients. Therefore, Health Level 7 (HL7) was introduced in 1987 to standardize EHR structure and development process [3]*.*

With entering of computers in medical institutions, record-keeping process has started to digitalize. At present time, in many developed countries EHRs are increasingly paperless, although some private practices continue to use a combination of paper-based and computerized records. Patient records are more accessible than ever before with data technology becoming increasingly portable and comprehensive. Current refinements in the medical records industry are aimed at the continued specialization of systems to further streamline workflows, boost productivity, and improve doctor-patient interactions. And so, it seems that EHRs will continue to make a mark in the healthcare industry for years to come [3].

## **What is OpenEHR?**

OpenEHR is a *technology for e-health consisting of open platform specifications, clinical models and software that together define a domain-driven information systems platform for healthcare and medical research. The principal architectural concepts include the patient-centric health record, clinical guidelines and decision support*. Solutions based on the published artefacts are implemented by vendors, provider institutions and research groups for use in various operational environments, including point of care, research projects and public health [4].

Benefits of the openEHR methodology and architecture include:

* Domain professionals directly define the content and other semantics of implemented (not IT professionals).
* Development may be largely implemented by low-code tools, enabling rapid development.
* Interoperability is an automatic outcome of the platform architecture rather than an ad hoc case-by-case problem.
* The platform approach enables a component-oriented healthcare IT economy based on published interfaces, which provides procurement the possibility of flexible and incremental purchasing from a wide variety of implementers [4].

Diagram

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## **Health Level Seven (HL7)**

Health Level Seven represent a set of ***international standards for transfer of clinical and administrative data between information systems*** employed by various healthcare providers. The HL7 standards were created by Health Level Seven International standards organization, and are adopted by other standards issuing bodies such as American National Standards Institute and International Organization for Standardization [5].

HL7 includes standards and guidelines to help software developers and healthcare providers store and uniformly move data, making sure that all documentation and other data remain consistent across all systems. For instance, the standards define how the data is packaged and moved including defining the language, data type, and structure of the data. [6].

HL7 consist of 7 sections, having different purposes and defining a new set of rules that may build on the previous set of standards:

1: Defines the standard system integrations and compliance methods.

2: States the foundational standards that users can build and helps define the standards and technology infrastructure they plan to use.

3: Helps link messaging and document standards for providers.

4: Details how electronic health records (EHR) are constructed and managed using profiles and models.

5: Outlines the methods used for implementation and includes support documents for other categories.

6: Explores the rules and references used to develop programming structures for software and aids in standards development as well.

7: Educates users and provides the tools to help aid in the development and adoption of HL7 standards.

Finally, HL7 standards represent a milestone towards interoperability and laid the groundwork for developing the more open and extensible Fast Healthcare Interoperability Resources (FHIR) as well as the adoption of APIs for health IT [7].

\* \* \*

# **Technical specification Kids EHR**

Kids EHR represents a prototype of EHR system, providing an easy framework for healthcare practitioners to store healthcare information of patients. The system structure is based on the HL7 FHIR standards.

## **Database structure**

The database of Kids EHR has a simple structure, consisting of two tables:

**“doctors”**  – contains information about system users

**“users”** – stores patients’ data (EHRs)

The database structure is presented on the Picture-1 below:

Graphical user interface, table

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## **Backend part, system files structure**

The backend part of the Kids EHR system is written in pure PHP 7.3., without use of additional frameworks. The EHR data as well as other information (e.g. doctors’ profiles) is stored in MySQL database, 5.7 version. It consists of 4 php files.

**EhrManager.php** – the class includes all the functions for managing CRUD actions with EHRs;

**Database.php** – the class manages connection to MySQL server;

**Login.php** – login class is responsible for user authorization function. Each authorization is being saved in the global variable “*session*”.

**Logout.php** – this script executes doctor logout function and the redirects doctor to the main page.

Login and logout functions are based on the code samples “PHP MySQL Login System” provided in the article [8] with additional modifications.

## **Frontend part**

The frontend part of Kids EHR is based on the HTML5 markup language. For the layout Bootstrap 5 templates were used with custom CSS3 code snippets. The behavior of the interface is programmed in JavaScript.

The front-end pages are generated by the following source files (PHP):

**Register.php** – this script generates HTML code of the Doctor registration page. Recommended password generation function (Javascript) is also included in this file

**Index.php** – the file generate HTML code of the main page, containing navigation menu, My EHRs table and static content about HER system.

## **Interface design, user manual**

The interface of Kids EHR is designed with simplicity in mind. It has a typical one-page structure with navigation links, scrolling the page to the corresponding sections. The main page has all the tools required for doctors to manage EHRs.

Timeline

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On the top part of the page there is a Doctor login form, where registered doctors can login into their accounts.

Graphical user interface, text

Description automatically generated

In the top right part, there is a **Sign-up** button, which redirects users to the Doctor Registration Page.

Graphical user interface, application

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Doctors must fill in ***username***, ***password, confirm password*** fields in order to create a account in the Kids EHR system. The “Recommended password” function generates a random password, strong enough to increase account security. When “**Use it**” button is clicked the password will be copied to the “Password” and “Confirm Password” fields. The “**Submit**” button saves data in the form fields and create a new doctor account in the “***doctors***” DB table. The “**Reset**” button clears all values entered in the form fields.

## **EHR table**

When a doctor is signed-in in his account, “My EHR” table displays on the main page. This table displays all the EHRs of the patients, related to this particular practitioner. Table is organized by 6 multiline columns, which represent information from a database field or a group of fields. Because each HER includes many field, table rows have a multiline structure, to avoid excessively large table and horizontal scrolling of the page:

- **columns 1-2** include personal data: first name, last name, email, address, date of birth, height, weight, gender

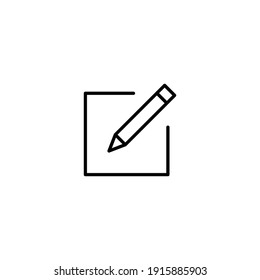
- **columns 3-4** display vaccination information of a patient

- **column 5** represents a textarea, where doctor can add additional details or comments in the plain-text form.

Timeline

Description automatically generated

In the rightest column of the table there are action icons, that allow editing and deleting each EHR entry.

**Edit** button: 

After clicking the “Edit” button of an EHR, a set of input fields appears in the selected row, where the patient information can be edited.

Graphical user interface, application

Description automatically generated

Clicking “**Update**” button saves all changes in the input field, “**Cancel**” button undo all changes and returns the row to the initial state (EHR display view). A combination of Javascript function and CSS parameter “display” makes input fields appear and disappear dynamically inside the table rows. Thus there is no need to refresh the page to activate or deactivate the editing mode.

**Remove** button: 

Clicking the button will remove EHR record from the **“My EHR”** table and delete corresponding entries in the “***users***” DB table.

## **Adding a new EHR**

Authorized users can create new EHRs using the “Add a new EHR” form.

Graphical user interface

Description automatically generated

This form displays under the “My EHR” table and represent a set of input field, where the EHR information about a new patient must be added. The “Add” button below the form sends to the database the information contained in the fields and creates a new EHR in the DB table “***users***”.

**Attention**: the new EHR will be displayed in the “My EHR” table only for the doctor who created it. Other doctors will not be able to see the EHR.

# **System Evaluation - Scoring SUS**

In order to have a more complete description of the system, evaluation of usability must be conducted. The System Usability Scale (SUS) methodology, created by John Brooke in 1986, will be used for evaluation of the Kids EHR system. It provides a quick and reliable tool for measuring the usability of a system based on a questionnaire consisting of ten questions. Each question includes five response options, varying from “Strongly agree” to “Strongly disagree” [9].

To begin with a ten-question survey has been composed in the Google Forms platform and answers were collected from two respondents.

Graphical user interface, text, application, email

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On the next step the SUS score will be calculated based on the collected answers. At first, the sums of scores for each question of the questionnaire were calculated according to the SUS methodology. Each item's score contribution in the questionnaire ranges from 0 to 4. For items 1,3,5,7 and 9 the score is equal to the scale position minus 1. For items 2,4,6,8 and 10, the score is equal 5 minus the scale position.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **X1 -1** | **5- X2** | **X3 -1** | **5- X4** | **X5 -1** | **5- X6** | **X7 -1** | **5- X8** | **X9 -1** | **5- X10** |
| **Position** | **Res 1** | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 |
| **Res 2** | 3 | 5 | 2 | 4 | 5 | 5 | 1 | 4 | 3 | 4 |
| **Score** | **Res 1** | 2 | 3 | 0 | 4 | 1 | 4 | 0 | 4 | 1 | 4 |
| **Res 2** | 2 | 0 | 1 | 1 | 4 | 0 | 0 | 1 | 2 | 1 |
| **Sum** |  | **4** | **3** | **1** | **5** | **5** | **4** | **0** | **5** | **3** | **5** |

Then, the sum of the sums of scores is calculated and multiplied by 2.5 to obtain the overall value of SUS:

**SUS score** = (4 + 3 + 1+ 5 + 5 + 4 + 0 + 5 + 3 + 5) \*2.5 = 35\*2.5 = **87.5.**

Thus, the SUS score is 87.5 and the value is higher than the critical value 68. Therefore, it can be concluded that the Kids EHR system has a high usability, according to the SUS methodology. It must be noted, however, that the evaluation based on the two respondents’ answers is not exhaustive enough. To get a more objective evaluation score, more responses must be used in evaluation.

# **Conclusions**

The information system represents a prototype of a EHR system for a kindergarten. The main objectives are managing information records and keeping vaccination records. The system has a single-page web-interface and includes functions that allow medical practitioners to register accounts, sign-in, and then create, modify, remove EHRs. Each doctor can see only his\her EHRs. The website also includes general information about EHRs.

The system is powered by PHP (7.3) and MySQL databases technologies. The frontend part is created using HTML5, Bootstrap 5, JavaScript and additional CSS code snippets. It was my first experience with Bootstrap, and I found it not flexible enough. When applying ready Bootstrap code snippets, sometimes it is hard to find and modify a style detail, like changing an element dimension or alignment.

Although the SUS score shows a high level of usability, the system still needs to be improved before using in production. For instance, there must be system administrator accounts to manage doctor profiles and assign EHRs to different doctors. Also, user profile page must be created to allow doctors to edit profile data, modify email, password and other information.

Problems, that emerged during the development process: the records are hard to be organized in a table. If we create 1 column for each field, there will be too many columns, the page will be too large.

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