Using open source technology to virtually implement a patient recruitment system for COVID-19 clinical research and disease monitoring in Greece

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Abstract

Introduction: Coronavirus crisis has activated healthcare administrations and personnel at highest level. Health informatics software tools and innovative e-governance policies can contribute to this point. In a previous study, we proposed a nationwide biomedical registry framework, that it could be valuable as a healthcare management tool of eGov Health, additionally.

Methods: Translating COVID-19 outbreak in health informatics terms, we developed virtual COVID-19 datasets to demonstrate a generic COVID-19 patient recruitment system in Greece. An open-source JS library was also used to develop a custom interactive map in order to display valuable information for clinical trial researchers and crisis managers.

Results: Results indicate our proposed application enhances the clinical trial processes to recruit eligible patients as a clinical trial cohort. Registered physicians - clinical researchers can overview available COVID-19 patients per health unit, nationwide. The implemented virtual web maps provide a helpful visualization of COVID-19 crisis in Greece.

Conclusion: Our proposed recruitment system could function both as a PRS and a DSS tool under infection diseases parameters. We strongly believe our application has generic eGov potential, both as an enhancing tool to design a clinical trial and as a healthcare crisis management tool.

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In a previous study in 2019, we introduced a virtual web-based national biomedical registry, named “HBR” (Hellenic Biomedical Registry), in order to enhance design conditions for clinical research in Greece, by integrating the clinical and molecular/genomic patient’s data [24]. Our proposed framework was based on WordPress open-source software (FOSS) technology following the modern trends for agile and minimum cost of development. Moreover, we used colorectal cancer as an example to prove the functionality and the effectiveness of our software. In brief, the HBR web platform aims to help clinical medical doctors – researchers (1) to overview the stored integrated clinical and molecular/genomic data of submitted patients - volunteers, and (2) to query the total number of patients per disease/condition and simultaneously per health unit, nationwide. The system designed to function both as a dynamic Patient Recruitment System (PRS) and as an Electronic Biomedical Patient Record (EBPR).

From a health IT perspective, COVID-19 clinical research trigger our virtual system to demonstrate anew its functionality as an underlined PRS for a clinical trial process related to COVID-19. Applying the coronavirus disease ICD-10 as new parameter in HBR system instead of colorectal cancer, the key objective of the present manuscript is to call out the healthcare crisis managers that our software philosophy could cover the objectives of a National COVID-19 Patient Registry. Eventually, it could be an effective health Decision Support Software (DSS) tool, among others, in the fight against the crisis.

Methodology

Managing our HBR application under the same configuration (as it was referenced in our previous published article), we briefly followed the next steps to re-evaluate the system perspectives in regard to coronavirus crisis: (a) we composed a virtual COVID-19 positive dataset of Greek patients, based on official ongoing COVID-19 information referred by the Hellenic National Public Health Organization [25], and we inserted it into our system database; (b) we preferentially used an open-source web mapping technology to geolocate our virtual COVID-19 data. Literature review was conducted in order to be up to date about the crisis: (a) we composed a virtual COVID-19 positive dataset of Greek patients, based on official ongoing COVID-19 information referred by the Hellenic National Public Health Organization [25], and we inserted it into our system database; (b) we preferentially used an open-source JavaScript library for web mapping, maintaining our principles for minimum cost of development. Connection strings with the HBR data sources were based upon the tutorial of the JavaScript library. Additional software implementation time was barely a week. Web maps source code is available upon request to our Laboratory including GeoJSON format. Figure 1 visualizes our methodology.

Results

In the HBR system, ICD-10 is one of the required data elements which a registered MD should properly fill in the online Electronic Case Report Form (eCRF) of his/her volunteer patient, as it is mentioned in our previous relevant publication for the Hellenic Biomedical Registry. In similar to previous colorectal cancer example, querying the HBR for standard COVID-19 ICD-10 codes in a virtual Health Unit ‘A’, the MD user gets the anticipated grid view of Figure 2(A). The data grid view provides dynamic sorting as well as editing grants according to HBR user essential role. Figure 2(B) displays the source SQL code for the accurate calculation of the number of COVID-19 cases per virtual health unit, by running multiple ‘select count’ SQL commands at the system’s backend, which eventually resulted to Figure 3(C). The displaying information of prospective COVID-19 patients provides a principal investigator/researcher the ability to rapidly create a prospective cohort of patients for an associated clinical trial.

Additionally, through the HBR data analytics web submenu items, we embedded a bar chart to display the disease progression of combined cases per leading city (Figure 3). The visualization of the direct comparison among distinctive regions could definitely lead official healthcare administrators to increase or to decrease control mechanisms of disease spread. Figure 4 displays a screenshot of the first developed interactive map, which virtualizes the aggregate number of COVID-19 cases by the comparable density of a color. A

Figure 1. Approach to properly implement HBR as a DSS valuable tool in coronavirus crisis. Step 1: implement appropriate COVID-19 patient datasets into the HBR database and progressively develop a web map to display the inserted data. Step 2: registered users query the database through the web-based UI for specific COVID-19 information. Step 3: requested information is displayed through data grids and interactive maps

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Figure 2. Screenshots of the virtual HBR outcomes using COVID-19 as an example, based on realistic published data by Greek authorities. HBR ID format is used as primary key in data imports. Image (A) displays COVID-19 cases of three virtual health units. The data grid view provides dynamic sorting as well as editing grants according to HBR user’s role. Image (B) displays the source SQL code for the calculation of the number of COVID-19 cases. Image (C) shows the view of the previous multiple “Select Count” SQL command. Following the present methodology, each registered clinical researcher can overview the total number of coronavirus patients per health unit, nationwide, and as a result to be able to monitor the disease progression or design a cohort of cases around SARS-CoV clinical studies.
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Figure 3. Screenshot of open-source developed bar chart in the HBR application, displaying the virtual COVID-19 patients per city (Based on factual report by official the Greek healthcare authorities April 10th, 2020, Eody.Gov.gr)

Figure 4. Screenshot of the embedded interactive Choropleth Map of Greece in the HBR application, displaying the virtual COVID-19 cases (Based on factual report by official the Greek healthcare authorities April 10th, 2020, Eody.Gov.gr). The comparable density of color regions depends on the number of cases. Each region mouseover emerges a popup info box.
Fig. 5. Screenshot of the embedded interactive Symbol Map of Greece in the HBR application, displaying the virtual COVID-19 cases (Based on factual report by official the Greek healthcare authorities April 10th, 2020, Eody.Gov.gr). A popup info box on each city - marker mouseover displays the total number of the cases per health unit and COVID-19 ICD-10 (U07.1 or U07.2).

Discussion

It is more than certain, that the following years the eGov Factsheets and indicators will be more than satisfactory for all EU countries, because of the healthcare crisis. Hence, our proposed system could be implemented as a new eGov Health policy contributing to the improvement of e-governance healthcare in Greece.

Furthermore, by watching the World Health Organization to promote “Solidarity clinical trial for COVID-19 treatments” via its webpage [27], we are persuaded that every scientific or technological idea related to the treatment of a pandemic cause should be considerable by the healthcare crisis managers. The pressure COVID-19 puts on health systems should promptly lead Health Administrations to speed the adoption of health informatics proposals and the deployment of innovative software solutions. An addition of an official healthcare manager role with specific grants on the HBR application menu and views could be implemented through the system administration dashboard. Subsequently, the limited HBR registered healthcare administrators could exploit our system to take decisions on healthcare crisis progression.

Because of coronavirus outbreak, the efficient data sharing is undoubtedly becoming an emerging issue. Discussions for intense collaborations between Biomedical and health IT scientists in order to implement effective information system solutions and eGov policies may soon arise, due to the need of rapidly design and execution of infectious SAR-CoV viruses -related clinical research or to the need of a future similar crisis management [28]. At last, previous research has indicated that individual immune response variabilities in infection.

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diseases (including SAR-CoV viruses) is regulated by host genomic factors variations, especially HLA genes polymorphisms [29-35]. Therefore, it could be advantageous for clinical physicians - researchers to conduct further clinical studies based on the exploitation of the easily further configured open-source HBR abilities to store molecular and genomic patient’s information.

From a web application security perspective, it must be emphasized that the personal data of the COVID-19 patients should be protected applying all necessary logical and physical anonymization techniques. But, information security measures are outside of the scope of our PRS demonstration at this time.

Conclusion

As overall conclusions, we believe that our previous published virtual biomedical registry covers the initial efforts to design and to conduct a clinical study under COVID-19 parameters. We have mentioned that the HBR application could literally work as a patient recruitment system as well as an intelligent decision support software tool for evaluating the potential of hospitalized patients or outpatients to participate in a research. In conclusion, we sincerely believe that our proposed PRS covers the requirements of a Hellenic COVID-19 registry, thus it could be easily implemented in the Greek eGov Health architecture and potentially in any eGov architecture, enhancing the recruiting processes of COVID-19 related clinical research.

Disclosure statement

No competing financial interests exists.

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