Smart Health Services for Epidemic Control

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Abstract – **At the time of an epidemic, it is necessary to have information about the epidemiological situation from verified sources. The lack of such information can lead to the spread of news from non-objective sources, irresponsible behavior of citizens, but also the spread of panic. Epidemic control is one of the topics in the field of smart health within smart cities. Based on electronic health records (EHRs), various information on the epidemiological situation in healthcare institutions can be extracted. This paper proposes a framework that enables several smart health services intended for epidemic control and ways to implement them. Examples of the realization of these services are given, based on EHRs from Health Center Nis.**

Keywords – **Epidemic control, Smart health services, e-Health, Electronic medical reports.**

I. Introduction

Today, information and communication technologies (ICT) are represented in various spheres of human activity, including solving everyday problems of urban residents. Examples of such problems that reduce the quality of life in cities are traffic jams, inefficient use of resources and the like. The result of efforts to solve these problems using modern technologies has led to the creation of a new concept whose description follows.

Smart city - A city that uses ICT to improve the living conditions of its citizens. The concept of a smart city, in addition to IC technologies, uses public resources and social information in order to increase the quality of life and public administrative services. Jimenez et al. in [1] defined a smart city as "a developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas: economy, mobility, environment, people, living, and e-government". Hence, improving services that contribute to better health of residents is also one of the key tasks of a smart city, and a prerequisite for solving them are e-Health and m-Health.

E-Health (electronic health) is innovative and more efficient provision of health services with the help of modern technologies and with a very high degree of system integration, and the possibility of mobility of both doctors and patients. Examples of e-Health are reflected through the possibility of electronic access to patients' health records, telemedicine, health knowledge management, mobile health, etc. In this way, easier and more successful treatment of patients and reduction of administrative restrictions when providing medical services are achieved. The advantages of e-Health are electronic monitoring and recording of patients' health status, access to this data anywhere and anytime, as well as fast transfer of information to users via telemedicine and internet services.

M-Health (mobile health) encompasses a range of health and medicine services that are realized by combining medical technologies and mobile and ubiquitous computing.

S-Health (smart health). The definition is similar to the definition of m-Health, with the emphasis that it is used within smart cities. In addition, s-Health and m-Health differ in the source information they use, and the flow of that information. For m-Health, the source information comes from the user / patient, while for s-Health, in addition to this information, it also uses collective data obtained from the infrastructure of the smart city. As for the difference in data flow, it refers to the fact that after processing in m-Health, the feedback is returned to the user, and in s-Health to the user, but also affects the collective data of the smart city [2].

Epidemic control. A special area within smart health is dedicated to epidemic control. The existence of electronic data on the health status of citizens, along with methodologies for their use and the collective intelligence of the city, improve the state's competencies in detecting and controlling epidemics. Citizens' activities and locations can be used to detect potentially new cases during an epidemic, effectively identify high-risk sites, and successfully manage an epidemic. Such methods are also applied in the detection and organization of other widespread health risks such as, for example, air pollution [3, 4].

At the time of writing this paper, there is a current pandemic of a COVID19 disease caused by new type of corona virus SARS-CoV-2. So, we are witnessing how much news on this topic are interesting for the public, how much there is talk of matching real data with those from public information systems and the like. The existing information system in Serbia, covid.rs, provides information of the number of deaths, the number of infected and the number of patients on a respirator per day [5]. Until 10.6. it was possible to monitor the epidemiological situation in the cities, but not after that. On the other hand, the epidemic curve is most often tracked on sites such as Worldometers and Endcoronavirus.org, etc. [6, 7].

The motivation for writing this paper stemmed from the fact that the existing public health services for epidemic control in Serbia are insufficient and could give citizens more details about the epidemic than they provide today. Our contribution is in identifying the relevant functionalities that

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smart health systems for epidemic control should provide and the proposal, design and development of a smart health platform for epidemic control and its most important services. The platform we propose works in real time, directly takes data from the medical information system and EHRs and ensures a large number of details, such as the prevalence of the virus by age structure, health facilities and an overview of the number of infected in the appropriate time interval.

The rest of the paper is organized as follows: the second section describes smart health solutions and services in related research, the third section describes the services within the epidemic control platform and describes how they are implemented, while fourth section gives an overview of their use. In the end, the conclusion and directions of further research are given.

II. Related Work and State of the Art

Smart health platforms that solve various problems using information technology have been described in numerous papers. The paper [8] describes a smart health care model with a decision support system model approach in public health service. The paper [9] describes IoT-based (Internet of Things) smart health services in order to support citizens in cases of health problems due to air pollution, and [10] describes a smart health platform that enables numerous services for interaction with patients.

Papers about the use of information technology in epidemic prevention and control vary from those aimed at finding a mathematical model and simulating the spread of the epidemic [11], to those describing platforms to inform citizens about the epidemic, and using technology to monitor the location of patients [12]. An IoT-based epidemic control platform is described in [13]. The paper [14] proposes the novel paradigm to control the Chickungunya virus. This paradigm has advantages such as timely recognition of infection and reducing the spread of infection, enhancements in the analysis process, monitoring patients regardless of their location, benefit for the doctors to work efficiently and for logical / precise decisions etc. The paper [15] analyzes the differences in the use of information technology for epidemic control in China and Western countries. The services available to our citizens to follow the information about the Covid19 epidemic are mentioned in the previous chapter.

III. EHRs and the Dataset

Electronic health reports are made mainly according to the internal needs of the hospital. They are needed by various actors such as: medical staff, patients whose health is documented, clinical research (medical researchers, pharmacists, epidemiologists, etc.), hospital management to monitor finances and inventory planning, budget, etc. EHRs may contain numerical and textual information. Medical data consist of structured, semi-structured and unstructured data and therefore require more complex processing involving the existence of appropriate lexical sources. The structural part contains the values of certain variables, so that they are the easiest to process (name, surname, year etc.). The semi-structured part gives descriptive values for some parameters, but the structure is still known (temperature, pressure, laboratory analysis etc.). The unstructured part consists of free text given by the doctor and consisting of symptoms, history, observations, conclusions etc. Unstructured data contain linguistically incomplete, informal and non-standard abbreviations, which complicates computer processing and analysis. For that, it is necessary to process the data in advance before the analysis in order to enter them in a standardized form.

At the time of writing, there is no publicly available corpus of medical reports in Serbian in electronic form. We used 5000 medical records in the Serbian language from 32 clinics belonging to the Health Center Nis (DZ Nis), collected by the information system MEDIS.NET [16]. The corps includes EHRs from 2018, which contains information about patients suffering from measles, because there was an epidemic of this disease in Nis at that time. This corpus is created in accordance with ethical standards, with de-identification of patients and medical staff.

Table I gives an example of the medical report we are processing. In it, we can identify the structural part that contains the date of the service, the name of the service, the diagnosis, the diagnostic code, the organizational unit in which the service was provided and the location of the service. Also, this report contains an unstructured section consisting of anamnesis. This part is more complex to process because it needs to extract the relevant data and convert it to a standardized format, suitable for further processing.

TABLE I
AN EXAMPLE OF PROCESSED EHR

Date of the service	02-03-18
Name of the service	First examination of adults
Anamnesis	povisena t 38.5 belicate naslage po ustima, kasalj, pulmo b.o, hiperemija grla (en. fever 38.5 whitish deposits in the mouth, cough, pulmo b.o, hyperemia of the throat)
Diagnosis	Morbili – measles
Diagnosis' code	B05
Organizational unit of the service	General medicine
Location of the service	Central building

I. The Architecture of the Platform

Based on the data available from the set of EHRs, it is possible to create several services that would provide insight into the epidemiological situation in real time and be a valid means of informing citizens. These services are based on medical data mining of medical reports. They could be displayed on a public health portal (Fig. 1) and would include the following use cases:

a) a report on how many people have a specific diagnosis in the city, on a daily, weekly and monthly basis. Based on this service, a visitor to the portal would be aware of the epidemic situation in his city, and whether the number of patients is increasing or decreasing. This report is created based on an analysis of the data obtained by entering in the structural field for the date of the medical service from the EHRs (Fig. 2a).

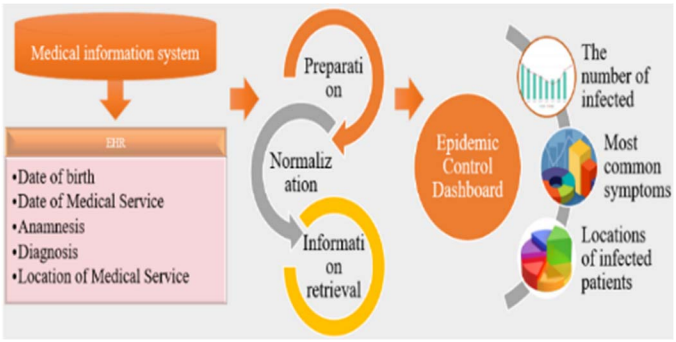

Fig. 1. Smart health framework for epidemic control

b) a report on the number of patients with a specific diagnosis, especially by health stations within the city. This would make the citizen aware of how many patients there are in his immediate vicinity. This report is created based on the analysis of data obtained by entering in the structural field for the location of the medical service from the EHRs (Fig. 2b).

c) a report on the presence of the disease in different groups based on age. Based on this, the citizen would be informed whether he or one of his relatives belongs to the risk group affected by the virus. This report is created based on an analysis of the data obtained by entering in the structural field for the patient's date of birth from the EHRs (Fig 3).

d) a report on the most common symptoms in patients diagnosed with the disease. Based on this report, the citizen would be more informed about the disease and could recognize the symptoms and in that case contact a doctor. This report is created based on the analysis of data obtained by entering in the non-structural field for leaving doctors' comments, from the EHRs. With adequate processing of this text, the symptoms can be extracted from this filed and can be shown on the diagram (Fig 4).

e) A simple questionnaire on the patient's current health condition (presence / absence of symptoms) to check whether to visit to the medical station for treatment or not.

All these services would enable the citizens to be constantly up to date with the epidemic and take measures to avoid or treat the disease, and in that way the consequences of the epidemic will be reduced.

The first three services require data analysis and visualization, which is not demanding, while the fourth requires specific word processing for proper symptom labeling. Analyzing the non-structural part of the EHRs we used, we came across abbreviations, spelling mistakes, different word forms and synonyms for the same symptoms. The anamnesis should be cleared of words that have no meaning, and words of meaning should be reduced to the same form. Abbreviations should also be processed and stored. There are also negative symptoms in the anamnesis, so the service would not show the true number of patients who have a symptom if the negation was not considered.

Natural Language Processing (NLP) techniques are required to extract information in the free text of the EHRs. The steps necessary for the extraction of information, in our case of symptoms, for the implementation of the fourth report are:

- Reduction to the one alphabet, abbreviation processing and tokenization. As these EHRs are written in Serbian, the free text can be found in Latin and Cyrillic. In order to transform the data into a standard format, in this step the text is translated into Latin, with special regard to letters with diacritical marks. After that, the abbreviations are marked, and then the sentence is divided into tokens.
- Deleting stop words - this step eliminates words that do not carry meaning.
- Determining negation - only a few negation symbols are used in medical reports, so the negation mark is attached to the close word, to indicate the possible absence of symptoms;
- Reduction on the basis - since the Serbian language has a rich grammar, words can be found in various forms, it is necessary to reduce on the basis. In the absence of a morphological dictionary, as well as for faster results, the base may be a prefix of length *n* or stem;
- Classification (labeling). After preprocessing the text, classification can be performed. Classification can be done using machine learning methods, taggers, but also rule based methods, if symptoms are marked in the data model.

These steps of normalization of medical reports in Serbian are described in detail in [17]. The symptoms shown in the diagram are labeled with methods shown in the paper [18].

II. The Realization of Smart Health Services

The epidemic control service shows the situation about the number of patients who have the appropriate diagnosis, how old they are, where they came for an examination, and what symptoms they had.

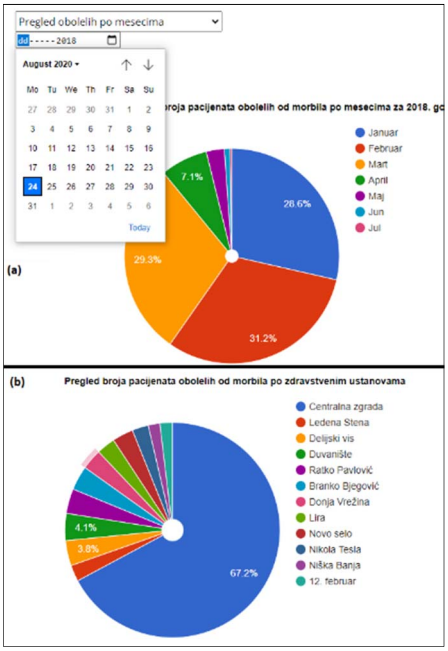

Fig. 2. Chart of patients (a) by months and (b) by health facilities

For the realization of this service, it is necessary that a part of the data stored in the EHRs in hospital systems be publicly available in order to extract data from them, i.e. the appropriate knowledge. Fig. 2 shows an overview of the number of patients by health stations and by months, the Fig. 3 presents patients by age groups, and Fig. 4 shows the number of patients with the most common symptoms (rash, cough, fever and pharyngeal hyperemia are extracted).

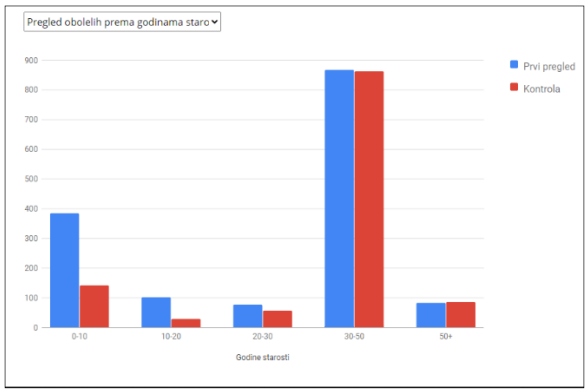

Fig. 3. Review of patients by age

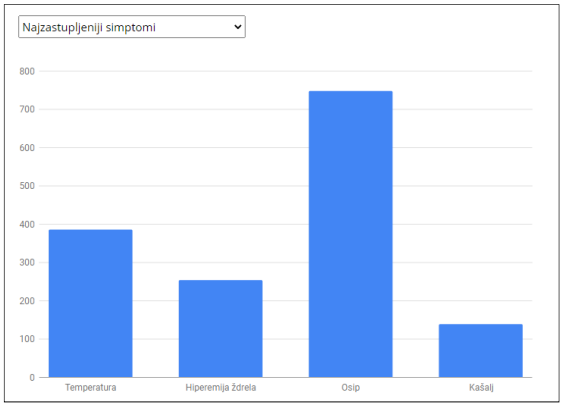

Fig. 4. Review of most common symptoms

III. Conclusion

The realization of health services is an important component of a smart city, especially in the field of epidemic control, in order to raise citizens' awareness of protective measures and to monitor the epidemic in their place and call a doctor on time. The paper proposes the necessary health services that would enable citizens to follow the epidemic situation in real time. These services are based on the existing information infrastructure, do not require special investments, and provide the population with a lot of verified information in the field of epidemic monitoring because they are centralized. Some of the proposed services have been implemented and briefly presented in the paper.

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