Extensions and adaptations of existing medical information system in order to reduce social contacts during COVID-19 pandemic

Aleksandar Milenkovic*, Dragan Jankovic, Petar Rajkovic

University of Nis, Faculty of Electronic Engineering, Laboratory for Medical Informatics, Aleksandra Medvedeva Street 14, 18000, Nis, Serbia

ABSTRACT

Objective: The main objective of this paper is the reduction of the COVID-19 pandemic spread by increasing the degree of social distancing by using and upgrading the existing Medical Information System (MIS).

Material and methods: The existing MIS MEDIS.NET, currently used in the largest health center in the Balkans, has been adapted and further developed.

Results: During the adaptation of existing MIS MEDIS.NET 4 new and 9 existing modules were developed. A quick questionnaire for the smart triage of patients was also implemented.

Discussion: The adapted MIS successfully influenced the reduction of social contacts within the Health Center Nis. The need for the arrival of children and their parents to receive appropriate health certificates for the school enrolment is reduced. The therapy of chronic patients has been prolonged for 6 months via an electronic pre-scription. An online service for the communication between patients and the chosen physicians is provided. Possible social contacts and exposure to the viral environment of patients are reduced by making appointments in extended slots and at determined physical locations. Patients are notified per SMS or email about the availability of chosen and physician on duty. The social distancing of patients and physicians is also established by sending laboratory analyses per email or SMS. Keeping the central registry for COVID-19 is enabled throughout the country.

Conclusion: The smart adaptation of MIS, and its collaboration with other state systems can significantly in-fluence the reduction of social contacts and thus mitigate the consequences of COVID-19 pandemic.

1. Introduction

The emergence and rapid expansion of major epidemics, besides the influence on the daily lives of people through changing health, eco-nomic, working style, social and political routines, also has a significant impact on existing information technology (IT) products, with a great emphasis on large-scale information systems (IS) which are exploited on a daily basis. During outbreaks, especially those with a pandemic character, the following key activities [1] which are updated with COVID-19 strategy [2] have been identified whose strict implementa-tion has an impact on the reduction of number of infected people and suppression of the spread of epidemic:

1 Movement reduction and social distancing (decreasing the number of possible contacts) especially for vulnerable groups (elderly people, chronic patients) [3],
2 Encouragement and promotion of universal face mask use in public

areas [4],
3 Good ventilation, regular temperature monitoring and hand hygiene [5],
4 Lowering the need of healthy people to come to environments with the huge probability of the viral pathogen presence (e.g. decreasing the arrival of healthy people to health institutions),
5 The earliest possible identification of infected patients (including infected healthcare workers) and their contacts,
6 Isolation of persons who are suspected to be infected with the virus [6] (the persons not yet diagnosed with the disease),
7 Monitoring persons during home isolation in order to check whether they follow the rules of self-isolation,
8 Make as many digital (government, administration, health such as telehealth [7]) online services as possible available to people to reduce their need to exit and be exposed to the infectious environ-ment.

* Corresponding author at: University of Nis, Faculty of Electronic Engineering, Laboratory for Medical Informatics, Aleksandra Medvedeva Street 14, Lab. 534, 18000, Nis, Serbia.

E-mail addresses: aleksandar.milenkovic@elfak.ni.ac.rs (A. Milenkovic), dragan.jankovic@elfak.ni.ac.rs (D. Jankovic), petar.rajkovic@elfak.ni.ac.rs (P. Rajkovic).
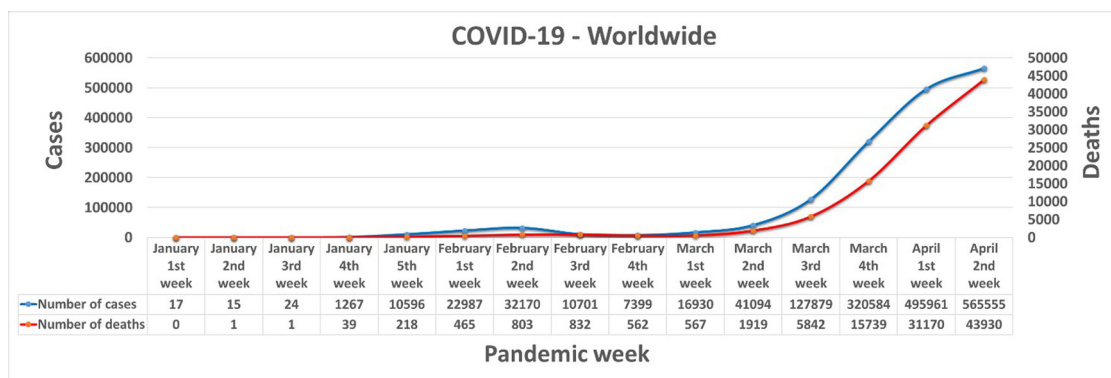
Fig. 1. Worldwide spread and trends of COVID-19 during the first 15 weeks in 2020. Data for visualization are collected from [22].

The main problem that naturally arises is the efficient suppression of the rapid spread of epidemic i.e. reducing the number of persons who could be exposed to the infection through the proposed key activities. The reduction of disease transmission is most efficiently conducted by socially distancing people from each other and reducing their contacts [8]. Additionally, educational campaigns which strengthen the understanding of the outbreak and adhere to mitigation strategies need to be conducted in order to raise awareness about the COVID-19 disease and its consequences. Some epidemics have the characteristic of rapid pathogen spread, which causes them with the high incidence of hospitalized and severely ill patients. Emerging of an enormous number of patients, suffering from the disease which causes the epidemic, within a short period of time, can become a major problem for the whole healthcare system of a country especially with an emphasis on the secondary or tertiary protection level. Even well-developed countries with the most sophisticated healthcare systems can easily experience the healthcare collapse during epidemics [9] (e.g. Italy [10], USA [11], Spain [12], UK [13]). The primary healthcare system in such circumstances needs to undertake significant steps in early diagnosing of ill patients and reducing the degree of contact in order to avoid the collapse of secondary and tertiary level. Besides engaging healthcare resources to combat the epidemic, the need emerges for an intensive use of IT solutions.

This paper presents the adaptation and extension of existing medical information system (MIS) as an efficient response to the rapid COVID-19 epidemic spread, mostly through influencing the reduction of social contacts and earliest possible identification of potentially infected persons.

The objective of this paper is increasing the degree of social distancing (decreasing unnecessary physical contacts in a healthcare institution and city in general) which is accomplished by adapting the existing MIS MEDIS.NET [14]. The implementation of social distancing is based on the following relationships: patient to patient and patient to healthcare worker. The adjusted MIS gave an efficient response to the rapid spread of pandemic caused by COVID-19. By adapting MIS MEDIS.NET a software support is granted to the Healthcare Centre Nis (HCN) to combat the fast-spreading disease COVID-19. The software support is provided to the following key proposed activities: 1, 4, 5, 6, 8.

2. Background and related work

The novel coronavirus appeared by the end of 2019 and is named SARS-CoV-2 [15]. It was discovered in China by the end of 2019 in the city of Wuhan, the province of Hubei [16]. The disease caused by the virus SARS-CoV-2 is named COVID-19. For COVID-19 the World Health Organization (WHO) assigned the urgent ICD-10 diagnosis U07.1 [17]. Since its emergence, COVID-19 is the center of attention of many researchers. One recent study [18] reviewed the virology, origin,

epidemiology, clinical manifestations, pathology and treatment of COVID-19 and compared it with SARS-CoV and MERS-CoV infections. According to its results the new virus is closely related to the virus SARS-CoV which appeared in November 2002.

The 138 hospitalized patients infected with COVID-19 in Wuhan had the following common symptoms: fever (136 [98.6 %]), fatigue (96 [69.6 %]) and dry cough (82 [59.4 %]). Chest computed tomographic scans of all infected patients showed bilateral patchy shadows or ground glass opacity in the lungs [19]. The COVID-19 disease in most of the cases affects older men with comorbidities and can lead to severe as well as life-threatening respiratory diseases. The average age of these patients infected by new coronavirus in Wuhan was 55.5 years (SD 13.1) and 51 % of them had some chronic disease [20]. The most vulnerable patients have chronic diseases such as diabetes, hypertension and cardiovascular disease with possible complications, which include acute respiratory distress syndrome (ARDS), RNAaemia, acute cardiac injury and secondary infection [21].

The Fig. 1 shows the exponential growth of the affected and deceased people worldwide infected by COVID-19 [22]. Due to prolonged lockdown and fear of infection, COVID-19 adversely affect the mental health of the general population throughout the pandemic [23]. After the emergence in China, the crisis centers became Europe and North America. Currently the most vulnerable countries in the world are the most developed countries with a quality and modern healthcare system: USA, Spain, Italy, France, Germany, UK (April 22, 2020) [24]. Owing to the character of COVID-19, the WHO marked the outbreak of virus SARS-CoV-2 as the pandemic on March 11, 2020.

The first case of the affected by the virus in the Republic of Serbia (RS) was recorded on March 6, 2020. The exponential growth of patients affected by COVID-19 is recorded in RS [25].

The Government of RS formed on April 3 the COVID-19 IS [26]. The aim of this IS is to carry out epidemiological surveillance related to COVID-19. Due to the exponential and easy spread of the highly contagious COVID-19 disease, it was necessary to rapidly adapt the existing MIS during the beginning of the COVD-19 pandemic.

Due to the exponential growth of the COVID-19 disease it is crucial to develop triage protocols in order to identify and isolate patients suspected of having the COVID-19 infection in COVID-19 temporarily hospitals or special departments in existing health institutions for the isolation of patients. In this way the disruption of normal medical care would be mitigated. A successful protocol for triage during a pandemic requires a more detailed planning, which involves a constant data collection: about the patient (demographic and medical data), data about availability of healthcare resources [27]. A patient portal-based COVID-19 self-triage and self-scheduling tool was created and it was made available to all primary care patients at the large academic health system at the University of California, San Francisco (UCSF) Health [28]. Based on the results, during first 16 days of use symptomatic patient triage dispositions were as follows: 193 emergent (24 %), 193

urgent (24 %), 99 nonurgent (12 %), 329 self-care (40 %) and sensitivity for detecting emergency-level care was 87.5 %. According to the research findings the integration of patient self-triage tools into electronic health record (EHR) systems has a great potential in improving the triage efficiency and preventing unnecessary visits during the COVID-19 pandemic.

The estimate of effects of physical distancing measures on the progression of the COVID-19 epidemic was conducted [29]. Synthetic location-specific contact patterns in Wuhan were used and adapted in presence of school and workplace closures as well as the general reduction in mixing in the community. Using an age-structured susceptible-exposed-infected-removed (SEIR) model the authors simulated the ongoing trajectory of the epidemic. They fitted the latest estimates of epidemic parameters and investigated the age distribution of cases. Lifting of the control measures, such as allowing people to return to work in a phased-in way was also simulated. The effects of returning to work at the beginning of March or April were investigated. Based on the results, physical distancing measures showed to be most effective if staggered return to work happened at the beginning of April, which reduced the average number of cases by more than 92 %. The authors summed up that if restrictions maintained until April, they would delay the peak of epidemic. Sudden lifting of measures could provoke an earlier secondary peak. Such a scenario can be avoided by relaxing the measures gradually.

The tools and methods developed for the identification of possible patients who suffer from some chronic disease show that the automatic summarization would help identify all patients with at least one record related to the diagnosis usually marked as chronic, with the final approval of medical professionals [30]. The results show that depending on the data filter definition, the total percentage of newly discovered patients with a chronic disease is between 35 % and 53 %, as expected. It is important to mark chronic patients during the regular physician's visit during the COVID-19 pandemic in MIS MEDIS.NET since they belong to the vulnerable and high-risk groups.

The use of smart technologies has been the focal point of many researches worldwide. Especially in recent times the researchers are focusing on developing phone applications which track infected and potentially infected people in order to suppress the spread of COVID-19. The Pan-European Privacy Preserving Proximity Tracing (PEPP-PT) [31] is a platform on whose development works a team of 130 researchers from 8 European countries. On the basis of this software national authorities remain free to decide how to inform persons that they were in contact with someone who was tested positive. World-renowned companies such as Apple and Google [32] are developing a smartphone platform that tracks the spread of COVID-19 by using proximity capabilities built into Bluetooth Low Energy transmissions, which enables the actual tracking of physical contacts of phone users who agreed to participate. The user who is tested positive for COVID-19 can enter the result into a health department-approved application. All other participating phone users who recently had a contact at the distance of approximately six feet with the infected user will be contacted by the application. During the largest Ebola epidemic in West Africa (2014–2016) researches developed an Ebola contact tracing (ECT) application for tracing contacts [33]. The authors compared results of the application developed with the existing paper-based system. Based on their research, the app-based contact tracing recorded 63 % of contacts of laboratory-confirmed cases, whereas paper-based contact tracing achieved the result of 39 % with often incomplete data. The developed smartphone application is linked to an alert central system to notify the District Ebola Response Centre of symptomatic contacts. The authors agreed that despite many challenges the use of application had benefits, such as improved data completeness, storage and accuracy.

The development of smart healthcare system is a highly important factor from the perspective of patients (e.g. better health self-management, timely and appropriate medical services can be accessed when needed), healthcare employees (e.g. reduce costs, relieve personnel pressure, achieve unified management of materials and information, and improve the patient's medical experience) and research institutions (e.g. reduce the cost of research, reduce research time, and improve the overall efficiency of research) [34]. The researchers emphasized the importance of new generation of information technologies, such as internet of things (IoT), mobile Internet, cloud computing, big data, 5 G, microelectronics, and artificial intelligence in order to build smart healthcare. Furthermore, Big Data Computational Epidemiology is a new and exciting multidisciplinary area that uses computational models and big data for identifying and controlling the spatiotemporal spread of disease through populations (e.g. the H1N1 influenza) [35].

In today's era of informatization many health care institutions are facing the need to rapidly improve their IT infrastructure to meet the challenges of modern times, such as the outbreak of COVID-19. The health facilities need to be prepared for the exponential growth of patients [36].

3. Materials and methods

On the territory of RS as MIS several solutions are used among which are, during the last 10 years, the most dominant 3, one of them being MEDIS.NET [37]. MEDIS.NET is MIS which is used in the southeast of Serbia in 25 healthcare facilities of the primary healthcare. It was developed at the Faculty of Electronic Engineering in Nis, in the Laboratory for Medical Informatics. MIS MEDIS.NET is licensed by the Ministry of Health of RS for the use in the primary healthcare on the territory of the whole country.

The city of Nis is the second largest city by land area and population in Serbia and represents the second huge center of disease in RS during the COVID-19 pandemic. There is only one health center in Nis which besides the central facility has 63 branches on the territory of Nis district. The HCN is the largest primary healthcare institution in RS and in the Balkans as per the number of patients who gravitate towards it (about half a million). More than 10 years MIS MEDIS.NET is intensively used in the HCN (since 2009 to date). The adaptation and extension of MIS MEDIS.NET in response to the pandemic is done especially for the needs of the HCN. During the adaptation of MEDIS.NET the data from the HCN database were used. That immense amount of structured data enabled the identification and division of several groups of patients who were most affected by the COVID-19 pandemic (Tables 1 and 2), as well as the development of additional software modules, which help healthcare workers to proactively act in the suppression of pandemic. Before the beginning of COVID-19 pandemic MIS MEDIS.NET did not have specifically developed software functionalities (modules, subsystems) which would help healthcare workers and patients to combat seasonal and exceptional pandemics.

The algorithm of triage of patients for the care of patients in critical conditions during the flu pandemic which utilizes Sequential Organ Failure Assessment (SOFA) score [38] was used for this research. This triage algorithm has 4 main components: inclusion criteria, exclusion criteria, minimum qualifications for survival and a prioritization tool. Guidance for making triage decisions during the first days to weeks of the influenza pandemic, if the critical care system becomes overloaded, was provided by the algorithm. The triage algorithm for the needs of the COVID-19 pandemic was adapted and implemented in the *Module for Smart Patients Triage (MSPT)* in MIS MEDIS.NET as a questionnaire. The Box 2 contains detailed inclusion and exclusion criteria in the triage protocol for critical care during the influenza pandemic [38]. Two items were added in the inclusion criteria section before the existing item A in the Box 2. These items are *1 - Contact with COVID-19 positive person, 2 - COVID-19 positive test*. The item *Kidney failure* was added in the exclusion criteria section under subsection I - *End-stage organ failure meeting the following criteria*. For each patient, physicians receive a digital questionnaire in EHR [39] that corresponds to the suggested items in the algorithm. After completing the questionnaire with medical data the SOFA score is received, based on which the

Table 1

Percentage of inhabitants as per age and risk category group in the city of Nis. The Risk category: LR – Low Risk, MR – Medium Risk, HR – High Risk, *HR – The Highest Risk.*.

Age Structured Category	Percentage of Inhabitants by Age Structured Category	Average Age	Standard Deviation	95 % Confidence Interval	Risk Category	Percentage of Inhabitants by Risk Category	Average Age	Standard Deviation	95 % Confidence Interval
[0−6]	4.27	3.19	2.26	[3.16, 3.22]	LR	14.21	9.86	5.37	[9.82, 9.90]
[7–18]	9.94	12.72	3.43	[12.69, 12.75]					
[19−34]	17.93	26.86	4.50	[26.83, 26.89]	MR	53.59	41.80	13.04	[41.75, 41.85]
[35−64]	35.66	49.31	8.77	[49.27, 49.36]					
[65−79]	18.15	71.33	4.31	[71.30, 71.36]	HR	18.15	71.33	4.31	[71.30, 71.36]
80+	14.05	86.50	4.45	[86.46, 86.53]	*HR	14.05	86.50	4.45	[86.46, 86.53]

* All data were collected from the database of Health Center Nis in the Republic of Serbia, covering Nis administrative district.

action and patient priority are determined.

4. Results

Since social distancing is one of the most efficient methods for the suppression of coronavirus certain modules of MIS MEDIS.NET were adjusted and the new ones were developed. The main objective was to equip MIS MEDIS.NET with well-developed and adjusted modules, which would further assist in the implementation of social distancing. Through the use of those modules the following results were achieved: the exposure to the coronavirus of vulnerable groups was minimized, the interaction based on the patient to patient and patient to healthcare worker relationship was reduced, the configurable questionnaire for fast patient triage was developed, the online communication between patients and physicians was established. In the continuation, modules from MIS MEDIS.NET which are most relevant to the coronavirus are presented. In the section that follows, it is also presented how these modules respond during the COVID-19 pandemic, especially during the first weeks since the introduction of the emergency state in RS.

4.1. MIS MEDIS.NET key modules used to combat COVID-19

In the Fig. 2 a block diagram of key modules from MIS MEDIS.NET and their connections is presented. The red modules in the diagram are completely new modules, developed especially so that MEDIS.NET could help the healthcare workers of HCN and patients during the COVID-19 pandemic. The green modules are pre-existing modules which were upgraded with additional functionalities.

4.1.1. Newly developed modules

Due to the COVID-19 pandemic the state service of *COVID-19 Republic IS* [26] was urgently developed and put into operation for the collaboration with existing types of MIS in RS. The integration of *COVID-19 Republic IS* with MIS MEDIS.NET enabled the online communication between patients and chosen physicians, as well as medical data exchange between them.

The algorithm of patients' triage who came to the health center for an examination during the state of emergency in the RS and the pandemic of COVID-19 is presented in the Fig. 3. The algorithm shows the modules of MIS MEDIS.NET which were used during triage of patients, one of them being *MSPT*, which is applied for triage at the waiting room. In *MSPT* chronic and acute patients are classified into 4 groups according to the degree of urgency (Green, Yellow, Red, Blue), which is calculated using the developed dynamic questionnaire (Fig. 4) according to the SOFA score [38] adapted for COVID-19. The questionnaires contain questions which can be answered after the laboratory analyses have been done and the results have been obtained, so it is first necessary to complete chosen biochemical analyses. There is a predefined set of biochemical analyses for COVID-19 cases. Using deep neural network (DNN) and the data from the database, the DNN model was developed and trained for the recommendation of biochemical analyses to physicians. Besides the COVID-19 predefined set of biochemical analyses, the system using the DNN developed and trained model, automatically offers additional biochemical analyses. Offered analyses depend on patient's current vital parameters and medical history. The physician at the end decides which recommended analyses can be accepted and also has the possibility to add new analyses. For the creation of dynamic questionnaires in MIS MEDIS.NET a special tool was developed, which enables the creation of a higher number of questionnaires. The questionnaires appear both in *MSPT* and the EHR. The emergence of questionnaires in some modules of MIS MEDIS.NET depends on the sets of privileges per modules.

Questions in the questionnaire can be dynamically adjusted via the specialized questionnaire creation tool. A set of questions is created for each questionnaire. The type of question is determined for each question (multiple-choice, free text, or numeric field). The difficulty level is determined for each answer to the multiple-choice question. Minimum and maximum question difficulty levels are defined for each question. For each questionnaire one or more decision-making thresholds are adjusted, based on which the condition of a patient is estimated after the completed questionnaire. Based on the score achieved and values of adjusted decision-making thresholds an appropriate system notification

Table 2

Top 10 chronic ICD-10 diagnoses with percentage of chronic patients and average age at Health Center Nis.*.

Chronic ICD-10 Diagnosis	Percentage of Chronic Patients	Average Age	Standard Deviation	95 % Confidence Interval
I10 - Essential (primary) hypertension	26.09	61.15	18.11	[61.05, 61.25]
E11 - Type 2 diabetes mellitus	7.02	66.49	15.70	[66.32, 66.65]
I20 - Angina pectoris	4.91	72.88	12.97	[72.71, 73.04]
I49 - Other cardiac arrhythmias	4.89	67.30	17.96	[67.06, 67.53]
J45 - Asthma	4.24	39.51	25.89	[39.15, 39.87]
J44.0 - Chronic obstructive pulmonary disease with (acute) lower respiratory infection	3.41	56.51	27.89	[56.08, 56.94]
N40 - Hyperplasia of prostate	2.30	72.44	12.20	[72.21, 72.67]
E10 - Type 1 diabetes mellitus	1.65	67.74	16.15	[67.38, 68.10]
H40 - Glaucoma	1.48	69.74	16.13	[69.36, 70.12]
N30.1 - Cystitis	1.16	52.03	23.47	[51.41, 52.65]

* All data were collected from the database of Health Center Nis in the Republic of Serbia, covering Nis administrative district.
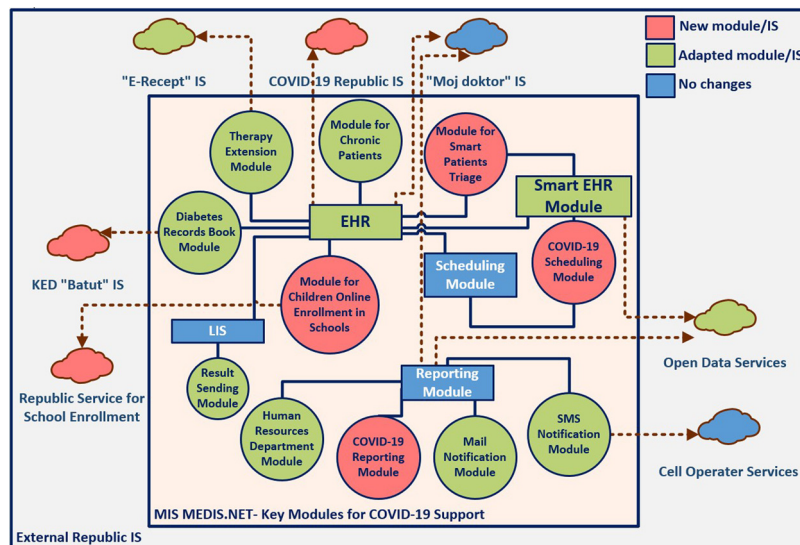
Fig. 2. MIS MEDIS.NET – Key modules and the most important connections among them.
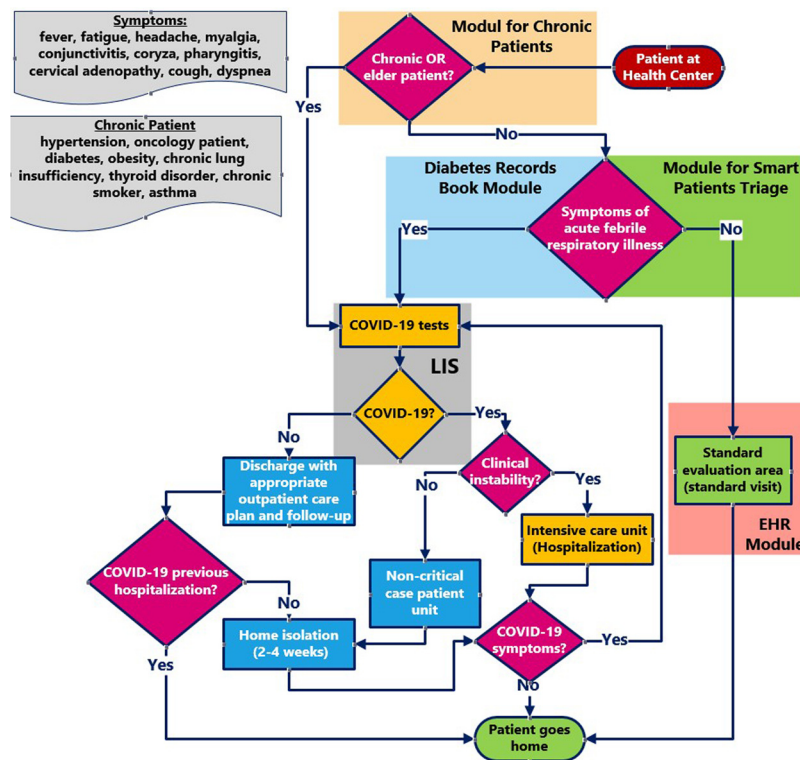
Fig. 3. A patient triage algorithm in a health center that uses MIS MEDIS.NET.

is created.

COVID-19 Scheduling Module is developed during the pandemic. This module enables smart scheduling of checkup appointments to certain identified critical groups of patients with huge enough time slots. Huge time slots enable contact avoidance of patients who belong to vulnerable groups at the health center. The system proposes the most suitable times of appointments for groups of patients identified according to following parameters: chronic patient, chronic diagnosis, acute state, age, gender, mobility of patients, risk factors, the date of previous visit.

Module for Children Online Enrollment in Schools (MCOES) enabled integration of MIS MEDIS.NET with *Republic Services for School Enrollment* which was developed by the Ministry of Education of RS. In this way medical certificates for school enrollment of pre-school and

school children from EHR are automatically delivered to the *Republic Services for School Enrollment*. Since children and their parents do not have to come to the health center to collect paper certificates as it was earlier the standard procedure, their degree of social distancing increased.

COVID-19 Reporting Module is an extension of the existing *Reporting Module* [40]. The module is realized in order to facilitate the creation of fast and efficient reports during the pandemic. The possibilities of creating jobs and periodic reporting are supported by sending automated reports via email to the heads of services and management of health center about the current situation related to the COVID-19 pandemic. This module enables the creation of dynamic reports and has a personalization option for each employee.

Fig. 4. The triage questionnaire as a part of *Smart Patient Triage Module*.

4.1.2. Pre-existing modules from MIS MEDIS.NET

Smart EHR Module enhances MIS MEDIS.NET making it a more advanced version. One of the functionalities of the module is the clustering of patients based on the demographic and medical data by using the DNN [41]. Logistic regression [42], Random Forest [43] and DNN are used for the implementation of subsystem for the smart identification and assessment of patients who will not come to the appointment with the chosen physician or/and to expensive diagnostic examinations for which a patient needs to wait, sometimes even for several months. This system has enabled patients to make appointments in overlapping slots [44] during the COVID-19 pandemic. For chronic patients [30] during a pandemic, a special submodule is used which suggests to general practitioners a possible therapy with the amounts of a medicine and the periodicity of taking a medicine, as well as possible referrals for specialist examinations [45]. Due to the use of new medicines during the treatment of infected patients with the COVID-19 infection, a subsystem is used as an assistance, which warns the physician whether the prescribed therapy corresponds to the established diagnosis. The subsystem also informs about the possible contraindications with other medicines the patient is using. A smart mobile reminder for taking the prescribed therapy [46] helps elderly and chronic patients during the pandemic not to forget to take the therapy at the predefined time. The developed subsystem for the use of existing data from MIS MEDIS.NET in the education of students at the Faculty of Medicine and newly employed workers, as well as for medical research [47], enables tracking and studying the COVID-19 disease at this stage. *Open Data Service* is used for obtaining the demographic data from available open data sets in Serbia [48].

Scheduling Module is responsible for recording scheduled/cancelled appointments of patients for an examination with chosen physicians/diagnostic devices. The centralized management of arranged checkup appointments and diagnostic procedures of patients was accomplished by integrating *Scheduling module* with the service/application *"Moj doktor" IS* [49].

Mail Notification Modul is responsible for providing service information to patients and health center employees via email. *SMS Notification Module* enables providing service information via SMS [50]. During the pandemic these modules were used for sending information to health care employees and patients.

In order to receive updated demographic data for each patient during the pandemic *Reporting Modul* was connected to *OpenData* available services of the RS [48].

LIS (*Laboratory Information System*) is a special IS, integrated with MIS MEDIS.NET. As a separate extension of *LIS, Result Sending Module* is developed. *Result Sending Module* aims at sending results to patients vie email or SMS. The increased degree of social distancing was achieved in this way, since patients did not have to collect results of biochemical analyses at the health center in person.

Human Resources Department Module contains additional data about the healthcare personnel who are infected with COVID-19. The data recorded for each healthcare worker include the date when he/she was diagnosed with COVID-19, the patients he/she interacted with, physical location of his/her stay in the healthcare facility while he/she was infected (28 days backwards from the moment of diagnosing the disease).

Diabetes Records Book Module was developed as an extension of *EHR* module. The module is connected to the state *KED "Batut" IS* (the central register of all patients suffering from diabetes in the RS). The module enables centralized detailed keeping of book of records of patients suffering from all types of diabetes in the country.

Therapy Extension Module enables forwarding of the prescribed therapy, which goes onto the prescription with the exact therapy validity date, to the centralized "E-Recept" IS. During the pandemic this module enabled the prolongation of therapy to chronic patients up to six months, thus avoiding unnecessary contacts.

Modul for Chronic Patients was created to keep the record about chronic patients. The module represents the register of chronic patients with established diagnosis and established therapy. The register enables fast check whether some patient has an established chronic diagnosis. For a chronic patient the whole course of treatment is shown. The lack of this module is currently its local availability (the register at the HCN). This module is of great importance in the triage of patients during the COVID-19 pandemic.

4.2. Benefits of MIS MEDIS.NET use during the COVID-19 pandemic

In the Figs. 5 and Fig. 66 a significant decrease of the arrival of patients during pandemic weeks at HCN is presented after the implementation of additional modules developed during the COVID-19
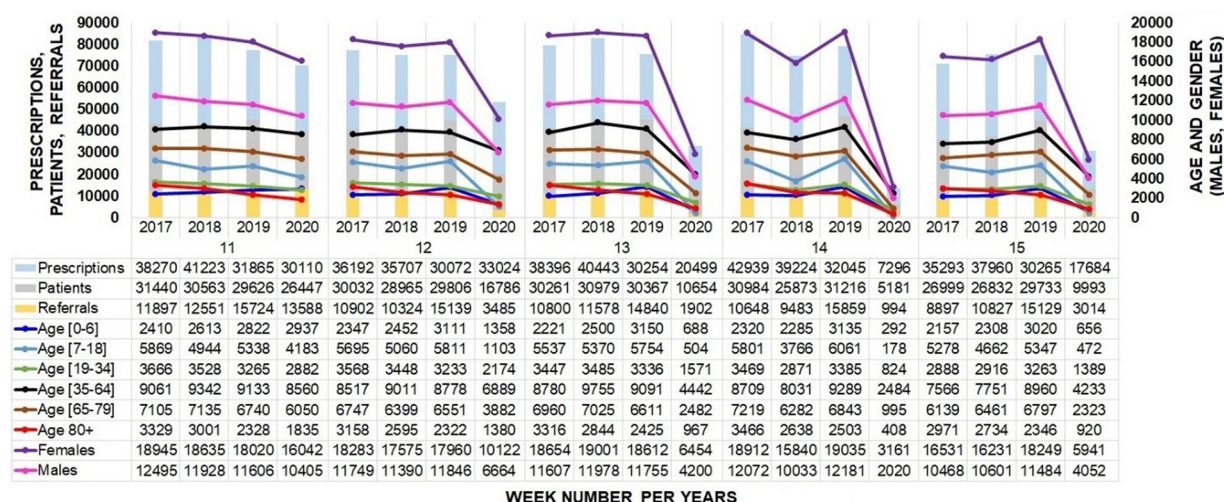
Fig. 5. Number of Prescriptions, Referrals, gander (Male, Female) and age structure ([0-6], [7–18], [19–34], [35–64], [65–79] and 80 +) at Health Center Nis during 11th, 12th, 13th, 14th, 15th week of 2017, 2018, 2019 and 2020.

| | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 |
		11				12				13				14				15		
Prescriptions	38270	41223	31865	30110	36192	35707	30072	33024	38396	40443	30254	20499	42939	39224	32045	7296	35293	37960	30265	17684
Patients	31440	30563	29626	26447	30032	28965	29806	16786	30261	30979	30367	10654	30984	25873	31216	5181	26999	26832	29733	9993
Referrals	11897	12551	15724	13588	10902	10324	15139	3485	10800	11578	14840	1902	10648	9483	15859	994	8897	10827	15129	3014
Age [0-6]	2410	2613	2822	2937	2347	2452	3111	1358	2221	2500	3150	688	2320	2285	3135	292	2157	2308	3020	656
Age [7-18]	5869	4944	5338	4183	5695	5060	5811	1103	5537	5370	5754	504	5801	3766	6061	178	5278	4662	5347	472
Age [19-34]	3666	3528	3265	2882	3568	3448	3233	2174	3447	3485	3336	1571	3469	2871	3385	824	2888	2916	2916	1389
Age [35-64]	9061	9342	9133	8560	8517	9011	8778	6889	8780	9755	9091	4442	8709	8031	9289	2484	7566	7751	8960	4233
Age [65-79]	7105	7135	6740	6050	6747	6399	6551	3882	6960	7025	6611	2482	7219	6282	6843	995	6139	6461	6797	2323
Age 80+	3329	3001	2328	1835	3158	2595	2322	1380	3316	2844	2425	967	3466	2638	2503	408	2971	2734	2346	920
Females	18945	18635	18020	16042	18283	17575	17960	10122	18654	19001	18612	6454	18912	15840	19035	3161	16531	16231	18249	5941
Males	12495	11928	11606	10405	11749	11390	11846	6664	11607	11978	11755	4200	12072	10033	12181	2020	10468	10601	11484	4052

WEEK NUMBER PER YEARS

pandemic.

In the Fig. 5. the most significant decrease in the number of patients' arrivals can be noticed from the 13th pandemic week of 2020, in comparison with the number of patients' arrivals during the same weeks of previous years. It was achieved by increasing the degree of social distancing. Due to the reduced number of patients, the number of specialist referrals was also lowered. By the implementation of additional module (MCOES), the number of arrivals of pre-school children (Age [0 − 6]) and school children (Age [7 − 18]) decreased significantly. MCOES enabled a direct transfer of medical certificates from the health center to schools, where the children were applying for an enrollment. A significant drop in arrivals was recorded as well for elderly patients, Age [65 − 79] and Age 80 + , which belonged to High Risk (HR) and The Highest Risk (*HR) categories respectively (Table 1). In most cases those were chronic patients with established regular therapies, which temporarily needed to be controlled and corrected. Those categories of patients represent the most vulnerable group that needs to be most protected during the pandemic. The integration of MIS MEDIS.NET with the *COVID-19 Republic IS* enabled online communication of patients with chosen physicians, which significantly influenced the decrease in number of patients belonging to Age [19–34] and Age [35–64]

categories. In this way increased social distancing was achieved in the patient to patient and patient to healthcare worker relationship. Reduced contact frequency at the HCN implies the reduced probability of infecting the medical staff. The amount of prescriptions (Fig. 5) was lower in comparison with the amount of prescriptions during previous years. The prescriptions item in the Fig. 5 includes the number of prescriptions as well, which were automatically prolonged to chronic patients.

From the 12th pandemic week, the number of patients who received referrals for specialist examinations decreased notably (Fig. 6). Out of all the patients who came to the HCN, the patients who were referred to specialist examinations were predominantly chronic patients. In most of the cases those were the patients with diagnosed I10 - Essential (primary) hypertension and E11 - Type 2 diabetes mellitus. The reduced number of patients at the HCN also influenced the decrease in the laboratory referrals. The Fig. 6 presents also the most frequent diseases for which prescriptions, referrals and laboratory orders were used.

All the patients who visited the health center showing some symptoms of COVID-19 went through the triage algorithm. Despite the lower arrival of patients (Table 3) the number of patients who were forwarded to the Clinics of Infectious Diseases and Pulmonology was higher in
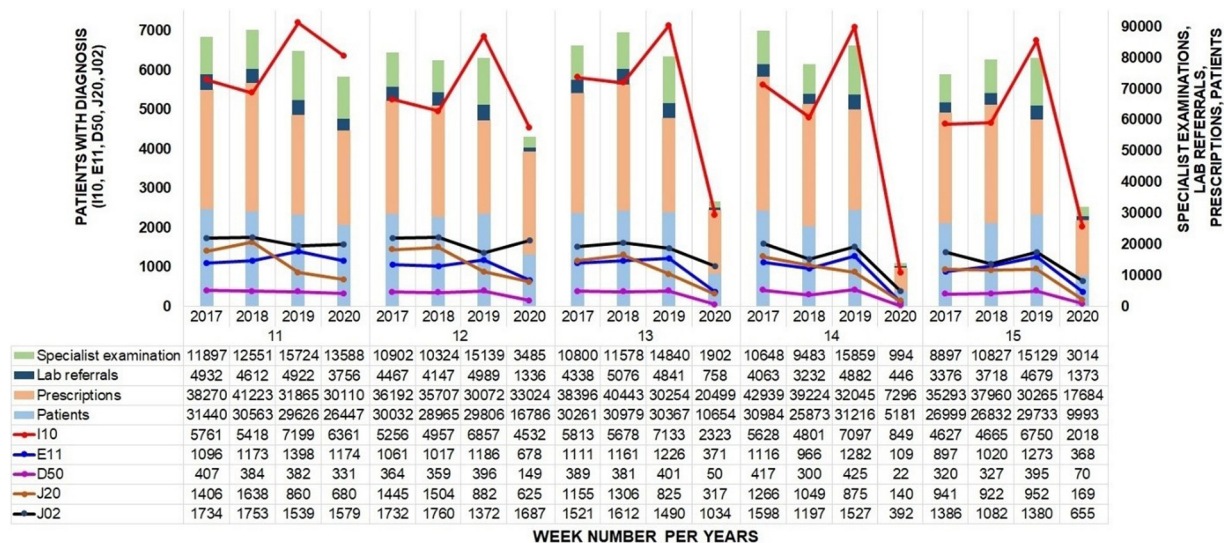

| | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 |
		11				12				13				14				15		
Specialist examination	11897	12551	15724	13588	10902	10324	15139	3485	10800	11578	14840	1902	10648	9483	15859	994	8897	10827	15129	3014
Lab referrals	4932	4612	4922	3756	4467	4147	4989	1336	4338	5076	4841	758	4063	3232	4882	446	3376	3718	4679	1373
Prescriptions	38270	41223	31865	30110	36192	35707	30072	20499	38396	40443	30254	20499	42939	39224	32045	7296	35293	37960	30265	17684
Patients	31440	30563	29626	26447	30032	28965	29806	16786	30261	30979	30367	10654	30984	25873	31216	5181	26999	26832	29733	9993
I10	5761	5418	7199	6361	5256	4957	6857	4532	5813	5678	7133	2323	5628	4801	7097	849	4627	4665	6750	2018
E11	1096	1173	1398	1174	1061	1017	1186	678	1111	1161	1226	371	1116	966	1282	109	897	1020	1273	368
D50	407	384	382	331	364	359	396	149	389	381	401	50	417	300	425	22	320	327	395	70
J20	1406	1638	860	680	1445	1504	882	625	1155	1306	825	317	1266	1049	875	140	941	922	952	169
J02	1734	1753	1539	1579	1732	1760	1372	1687	1521	1612	1490	1034	1598	1197	1527	392	1386	1082	1380	655

WEEK NUMBER PER YEARS

Fig. 6. Number of Specialist examinations, Lab referrals, Prescriptions, Patients and most frequent diagnoses (I10, E11, D50, J20, J02) at Health Center Nis during 11th, 12th, 13th, 14th, 15th week of 2017, 2018, 2019 and 2020.

Table 3
Total number of patients referred to infectious clinic (IC) and pulmonology (P).*.

Year	Referral Type	Week 11 (%)	Week 12 (%)	Week 13 (%)	Week 14 (%)	Week 15 (%)	Total Referrals
2020	P	15.57	12.02	22.95	23.50	25.96	366
	IC	18.41	10.79	20.63	22.86	27.30	315
2019	P	25.45	17.27	21.82	19.55	15.91	220
	IC	25.26	19.11	18.77	16.04	20.82	293
2018	P	29.30	15.81	22.79	15.35	16.74	215
	IC	25.35	17.37	20.66	18.31	18.31	213
2017	P	19.34	19.89	18.78	25.41	16.57	181
	IC	20.69	23.71	23.28	18.97	13.36	232

* All data are collected from the database of Health Center Nis in the Republic of Serbia.

comparison with last years. Taking into consideration that the number of arrivals of patients at HCN was in general reduced (Figs. 5, 6), the increase of such referrals was significant. COVID-19 as a significant manifestation had a rapid change of health condition on the lungs of a patient, so patients were after completing triage urgently referred to already mentioned external clinics for urgent further diagnostics.

The overview of patients who completed triage (their number and percent) during the 13th, 14th, 15th pandemic weeks is presented in 4 categories in the Table 4. The highest number of patients was with a Green priority. Those were patients who could be in home isolation, patients who were tested and not diagnosed with COVID-19, although they showed some infection symptoms or were in contact with infected or potentially infected persons. Patients with a Yellow priority had a clear picture of disease and were hospitalized in temporary COVID-19 hospitals. Patients with a Red priority were confirmed COVID-19 cases who also had some chronic disease and belonged to highly vulnerable groups (Table 1). These patients were hospitalized and required constant monitoring. Patients with a Blue priority needed to be hospitalized and were directly transported from home to COVID-19 hospitals.

5. Discussion

One of the most significant and most efficient measures in the suppression of COVID-19 pandemic is increasing social distancing. In order to increase social distancing in a patient to patient and patient to healthcare worker relationship, additional modules in MIS MEDIS.NET were developed. The additional modules enabled the implementation of social distancing within healthcare institutions, where at the same time

Table 4
Categories assigned by triage at the health center using *Module for Smart Patient Triage*.*.

Priority	Pandemic Weeks		
	13	14	15
Highest priority	149 (19.7 %)	158 (35.4 %)	181 (13.2 %)
- Red - Hospitalization			
Intermediate priority	153 (20.2 %)	42 (9.5 %)	444 (32.4 %)
- Yellow - Hospitalization/COVID19-Hospitals			
Self-Care	456 (60.1 %)	246 (55.1 %)	748 (54.4 %)
- Green - Home isolation			
*Hospitalization	0 (0%)	0 (0%)	0 (0%)
- Blue -			
Total patients on triage	758	446	1373

* Patients who need to be hospitalized were directly transported from home to COVID-19 hospitals.

the concentration of viral pathogen is high, as well as the probability of infection during the COVID-19 pandemic. By reducing contacts, the quality of medical services provided to patients was not impacted, on the contrary, the quality was increased since medical staff was able to dedicate more time to the patients who came to examinations (the number of patients in the HCN decreased). The decreased number of patients at the HCN, which represents the primary healthcare institution, enabled the medical staff to engage in special COVID-19 hospitals and infirmaries on the territory of the city of Nis as a medical support. In this way the healthcare capacity during the combat against the COVID-19 disease increased, where each physician and nurse represented a valuable resource during the new pandemic. The module developed for triage enabled fast detection of infected patients by the novel virus and prompt actions in order to provide quick and quality medical care. Besides that, more difficult cases of the coronavirus infection were transported into the specialized COVID-19 hospitals. Certain reports from MIS MEDIS.NET enabled the Crisis Staff in the city of Nis to efficiently trace potentially infected persons and medical staff, which was an important measure during the pandemic to avoid having a huge number of infected healthcare employees by the novel virus. In the continuation of discussion, it is presented how MIS MEDIS.NET with additionally developed modules during the COVID-19 pandemic responded to the combat against the pandemic from the perspective of increasing the degree of social distancing.

MCOES reduced the need of children and their parents to visit the HCN to receive paper health certificates for the enrollment of children in primary or secondary schools. In this way the stay of children and their parents in the rooms with the high probability of COVID-19 infection presence was prevented. *MCOES* enabled significant reduction of their arrival at the health center.

For chronic patients, the therapy duration does not have a time limit, and control checkups are planned every 3 months. The established therapy is corrected/confirmed during control checkups. Due to the COVID-19 pandemic with the help of *Therapy Extension Module* the duration of prescribed therapy to chronic patients was extended to 6 months. In this way the number of arrivals of chronic patients to the chosen physician for a control checkup and extension of chronic therapy was reduced. A patient could take the extended therapy directly at the nearest pharmacy or upon a special request could receive it to a home address. The aim of such changes was to reduce the number of contacts of chronic patients, as well as their movement and circulation at HCN and outside of their homes. Fig. 6 clearly shows the reduction of the number of arrivals of chronic patients suffering from hypertension (ICD-10 I10 - Essential (primary) hypertension) and diabetes (ICD-10 E11 - Type 2 diabetes mellitus). During the 12th pandemic week via *Therapy Extension Module* the therapy was extended to all chronic patients with the validity of 6 months. Due to the reduced physical movement during the pandemic week there were sporadic cases that had to contact the chosen physician to change the therapy because of problems with hypertension. The online consultation with a chosen physician significantly helped those patients. Due to the extension of therapy validity for chronic patients, the number of arrivals of patients to the physicians of various specialties was reduced (Fig. 6, Specialist examination). A significant decrease in the number of arrivals was noticed also for patients with diagnosed hypertension and diabetes, who actually belong to the most vulnerable category during COVID-19. By adapting MIS the number of their arrivals at the HCN was significantly reduced, at the same time the degree of their social distancing was increased and exposure to the viral environment was reduced.

The information about available free appointments and scheduled checkups, as well as about the availability of chosen physicians from *Scheduling Module* MIS-a MEDIS.NET is available to patients via the online portal *"Moj doktor"* IS-a [49].

Smart EHR Module also enabled scheduling of overlapping appointments during the state of emergency and COVID-19 pandemic. This mode of appointments scheduling was used for the patients who

did not have visible COVID-19 symptoms. The aim of this feature was to increase the occupancy rate of available appointments for medical checkups. Due to the COVID-19 pandemic, 62 % of patients were not coming to scheduled appointments which is a decrease in the number of patients who come to scheduled appointments on a regular basis. One of the main reasons for such a decrease was that the movement of patients was limited during the state of emergency on the territory of the RS. In order to obey the movement time limitations, patients were coming to the HCN outside of the scheduled time slots, when they could go out. Consequently, the scheduled time slots remained empty and available. Since the 12th week of 2020 the number of scheduled appointments with chosen physicians dropped even for 76 %.

SMS Notification Module and *Mail Notification Module* were used during COVID-19 pandemic for the constant notification of all patients about general issues: advice for the conduct of patients during COVID-19 pandemic, patients were informed about the opening hours of certain services, available appointments of a chosen physician if the time for the control checkup approached. One of the main issues was that not all patients (23 %) had email addresses and cell phone numbers inserted in the database.

Result Sending Module is aimed at sending the results of biochemical analyses to patients via email or SMS. The objective of the module is to reduce the contacts among patients and healthcare workers at the counter of the Department for Biochemical Laboratory while receiving the results of analyses. Also the smart notification of patients via emails is supported. The system informs a patient to urgently call a chosen physician depending on the results of marked analyses for the notification. Those notifications are forwarded to epidemiologists. The number of laboratory referrals and analyses significantly dropped (Fig. 6). However, the patients who went to the biochemical laboratory to give samples gladly accepted to receive the results per SMS or email. The problem appeared with patients who did not have access to computers. The percentage of such patients out of all patients who had laboratory referrals during pandemic week was 28 %.

Reporting Module enables the creation of geographic division, analysis and prediction of spatial expansion of infection caused by COVID-19 pandemic according to: areas, municipalities, parts of cities, neighborhoods, work place (according to institutions, factories, companies), regions.

The most significant decrease of arrivals of patients at the HCN was recorded during the 13th, 14th and 15th pandemic week. It was influenced by the developed modules which were distributed to the HCN as they were developed and adapted. The greatest decrease so far was recorded in the 14th week of 2020 (Figs. 5, 6). During the 13th pandemic week the integration with COVID-19 IS was completed so patients started to significantly communicate online with chosen physicians. At the same time, the number of their arrivals at the HCN decreased, which means that contacts and the stay in the environment with high virus presence incidence were reduced.

The age structure of patients who were coming the most during pandemic weeks was from 35 to 65 years of age (Fig. 5). The number of arrivals of elderly patients (age 65+) decreased immensely, which enabled their social distancing from other patients at the HCN.

The significant data for the Crisis Staff who managed the actions aimed at the suppression of the COVID-19 spread were the data about the persons who were coming to physicians for examinations, during the period when the physicians were infected, and who were later diagnosed with the presence of COVID-19 (14–28 days before registering the disease). These data were provided by *COVID-19 Reporting Module* and *Human Resources Department Module.*

The University of California, San Diego Health (UCSDH) incorporated a series of EHR enhancements created to support the rapid deployment of new regulations, procedures, and protocols across a healthcare system to combat the COVID-19 pandemic [51]. They developed the multimodal COVID-19 screening processes, such as telephone calls, direct email, and EHR messaging, which take place before personal encounters. Since triage protocols were developed as multiple templates and embedded in EHR, they can be easily updated for screening purposes. This functionality for the creation of triage protocols is similar to the presented triage questionnaire in *Smart Patient Triage Module* which is also configurable. As a good solution to avoid unnecessary patient and staff exposure, they developed the Patient Facing Technology which includes video visits for outpatients, and it is achieved by moving in person clinic visits to telemedicine-based visits. MIS MEDIS.NET achieved the wider degree of social distancing using The *Therapy Extension Module* and *MCOES*. The *COVID-19 Reporting Module* is similar to the UCSDH COVID-19 operational dashboard, from the perspective of constant COVID-19 pandemic reporting. The authors from UCSDH created a predefined set of laboratory analyses especially for COVID-19, with the possibility of adding additional analyses. In MIS MEDIS.NET during triage besides a standard set of analyses for COVID-19, the system proposes additional analyses, which can be accepted or denied by the physician. The authors argue that the EHR is a necessary tool in supporting the clinical needs of a health system during the COVID-19 pandemic management.

One of the limitations of this study is that the top 10 chronic ICD-10 diagnoses did not include psychiatric illnesses such as depression. Psychiatric patients were deprived of psychiatric care and resulted in more severe levels of depression and anxiety during COVID-19 pandemic [52]. Workers are reluctant to taking time off work to attend hospital/clinic during COVID-19 pandemic [53] and the MIS MEDIS.NET may help them to book appointment. Future research is required to extend the application of MIS MEDIS.NET to psychiatric patients and workers. Furthermore, MIS MEDIS.NET can work with smartphone applications to deliver counselling [54], rehabilitation [55], support caregivers [56] and monitor symptoms [57].

6. Conclusions

Since the coronavirus has potential for long lasting global pandemic with huge mortality rates and overloaded health systems, currently the only possible prevention is case isolation, contact tracing and quarantine, physical distancing, and hygiene measures [58]. A key approach to avoid the exceeding of health care capacities is by successfully implementing social distancing as a measure to control the spread of COVID-19. In order to achieve this, prolonged social distancing might be required until 2022 [59]. The newly upgraded system MIS MEDIS.NET was designed to assist the health care system of the Republic of Serbia to reduce the number of infected patients by implementing the measures of contact tracing and social distancing. This paper presents upgrades and adaptations of existing MIS MEDIS.NET during first 4 weeks from the beginning of the state of emergency and significant results which were achieved in reducing the following types of contacts: patients to patients, patients to healthcare workers at the health center. The proposed triage of patients during COVID-19 is a critical functionality for quick actions in case of the patients in critical conditions. Additional work is needed to upgrade the triage module with additional cases of use and to be available online to patients for self-triage. The results achieved by adapting MIS MEDIS.NET for the needs of COVID-19 pandemic and the experience acquired can also be used during other epidemics around the world (e.g. seasonal flu epidemic, jaundice epidemic, smallpox epidemic).

The next steps in the development of MIS MEDIS.NET aiming at the reduction of contacts and identification of potentially infected persons and endangered areas would be the integration with the geographic information system of the city of Nis. The development of mobile applications and their integration with MEDIS.NET could significantly assist epidemiologists in easier identification of potentially infected persons.

Authors contributions

The following contributions are made by the authors:

Aleksandar Milenkovic, Dragan Jankovic and Petar Rajkovic made initial design of system functionalities;
Aleksandar Milenkovic and Dragan Jankovic lead the system development and later deployment to the production environment;
Aleksandar Milenkovic and Petar Rajkovic extracted the data and performed analysis and data interpretation;
Aleksandar Milenkovic and Petar Rajkovic made a literature review;
All the authors made initial article draft;
All the authors revised and made a final approval of the submitted version.

Funding sources

Summary Table

What was previously known on the topic:
Social distancing is one of the most significant measures in suppressing the spread of a virus during epidemics and pandemics (such as the current COVID-19 pandemic). Initially, medical information systems were not created for the purposes of social distancing.
What this study added to our knowledge:
The adequate adaptation and upgrading of medical information systems can significantly increase social distancing by reducing patient to patient and patient to healthcare worker contacts. By customizing the medical information system social contacts can be significantly reduced and the spread of the virus slowed down without severely disrupting people's lives. The accurate triage is essential when there are not enough tests and when the laboratory capacities for samples processing are limited.

Declaration of Competing Interest

Medical information system MEDIS.NET, whose usage overview is presented in the submitted work, is a result of a joint project of the Laboratory of Medical Informatics and Health Center Nis. As a commercial product, it is sold to other public health centers in the Republic of Serbia.

Aleksandar Milenkovic and Dragan Jankovic received personal fees as full members of Laboratory of Medical Informatics.

During the conduct of this research, Petar Rajkovic received no financial compensation, but was allowed to use statistically processed data for other researches.

Acknowledges

References

[1] WHO, Infection Prevention and Control of Epidemic- and Pandemic-Prone Acute Respiratory Infections in Health Care, World Health Organization https://apps. who.int/iris/bitstream/handle/10665/112656/9789241507134_eng.pdf?sequence=1, 2014.

[2] World Health Organization, COVID-19 Strategy Update, (2020), p. 18 (Accessed 23 May 2020), https://www.who.int/docs/default-source/coronaviruse/covid-strategy-update-14april2020.pdf?sfvrsn=29da3ba0_19.

[3] P.G. Walker, C. Whittaker, O. Watson, et al., The Global Impact of COVID-19 and Strategies for Mitigation and Suppression, Imperial College London, 2020, https://doi.org/10.25561/77735.

[4] C. Wang, R. Pan, X. Wan, Y. Tan, L. Xu, C.S. Ho, R.C. Ho, Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China, Int. J. Environ. Res. Publ. Health 17 (2020) 1729, https://doi.org/10.3390/ijerph17051729.

[5] W. Tan, F. Hao, R.S. McIntyre, L. Jiang, X. Jiang, L. Zhang, X. Zhao, Y. Zou, Y. Hu, X. Luo, Z. Zhang, A. Lai, R. Ho, B. Tran, C. Ho, W. Tam, Is returning to work during the COVID-19 pandemic stressful? A study on immediate mental health status and psychoneuroimmunity prevention measures of Chinese workforce, Brain Behav. Immun. (2020), https://doi.org/10.1016/j.bbi.2020.04.055.

[6] A. Wilder-Smith, D.O. Freedman, Isolation, quarantine, social distancing and community containment: pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak, J. Travel Med. 27 (2020), https://doi.org/10.1093/jtm/taaa020.

[7] J. Wosik, M. Fudim, B. Cameron, Z.F. Gellad, A. Cho, D. Phinney, S. Curtis, M. Roman, E.G. Poon, J. Ferranti, J.N. Katz, J. Tcheng, Telehealth transformation: COVID-19 and the rise of virtual care, J. Am. Med. Inform. Assoc. 27 (2020) 957–962, https://doi.org/10.1093/jamia/ocaa067.

[8] A.C. Hayward, S. Beale, A.M. Johnson, E. Fragaszy, Public activities preceding the onset of acute respiratory infection syndromes in adults in England - implications for the use of social distancing to control pandemic respiratory infections, Wellcome Open Res. 5 (2020) 54, https://doi.org/10.12688/wellcomeopenres.15795.1.

[9] ECDC, COVID-19 Situation Update Worldwide, as of 23 May 2020, European Centre for Disease Prevention and Control, 2020 (Accessed 23 May 2020), https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases.

[10] S. Boccia, W. Ricciardi, J.P.A. Ioannidis, What other countries can learn from Italy during the COVID-19 pandemic, JAMA Intern. Med. (2020), https://doi.org/10.1001/jamainternmed.2020.1447.

[11] L. Hook and H.Kuchler, How Coronavirus Broke America's Healthcare System, FT Magazine https://www.ft.com/content/3bbb4f7c-890e-11ea-a01c-a28a3e3fbd33, 2020, (Accessed 23 May 2020).

[12] C. Arango, Lessons learned from the coronavirus health crisis in Madrid, Spain: how COVID-19 has changed our lives in the last 2 weeks, Biol. Psychiatry (2020), https://doi.org/10.1016/j.biopsych.2020.04.003.

[13] R. Mason, Coronavirus: London Hospitals Facing "Tsunami" of Patients, The Guardian https://www.theguardian.com/world/2020/mar/26/london-hospitals-facing-tsunami-of-coronavirus-patients-overwhelmed, 2020, (Accessed 23 May 2020).

[14] P. Rajkovic, D. Jankovic, A. Milenkovic, Developing and deploying medical information systems for Serbian public healthcare: challenges, lessons learned and guidelines, Comput. Sci. Inf. Syst. 10 (2013) 1429–1454, https://doi.org/10.2298/CSIS120523056R.

[15] D.M. Morens, P. Daszak, J.K. Taubenberger, Escaping Pandora's box—another novel coronavirus, N. Engl. J. Med. 382 (2020) 1293–1295, https://doi.org/10.1056/NEJMp2002106.

[16] C.-C. Lai, T.-P. Shih, W.-C. Ko, H.-J. Tang, P.-R. Hsueh, Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): the epidemic and the challenges, Int. J. Antimicrob. Agents 55 (2020) 105924, , https://doi.org/10.1016/j.ijantimicag.2020.105924.

[17] WHO, Emergency Use ICD Codes for COVID-19 Disease Outbreak, World Health Organization https://www.who.int/classifications/icd/covid19/en, 2020, (Accessed 22 April 2020).

[18] M. Xie, Q. Chen, Insight into 2019 novel coronavirus — an updated intrim review and lessons from SARS-CoV and MERS-CoV, Int. J. Infect. Dis. 94 (2020) 119–124, https://doi.org/10.1016/j.ijid.2020.03.071.

[19] D. Wang, B. Hu, C. Hu, F. Zhu, X. Liu, J. Zhang, B. Wang, H. Xiang, Z. Cheng, Y. Xiong, Y. Zhao, Y. Li, X. Wang, Z. Peng, Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China, JAMA 323 (2020) 1061, https://doi.org/10.1001/jama.2020.1585.

[20] N. Chen, M. Zhou, X. Dong, J. Qu, F. Gong, Y. Han, Y. Qiu, J. Wang, Y. Liu, Y. Wei, J. Xia, T. Yu, X. Zhang, L. Zhang, Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study, Lancet 395 (2020) 507–513, https://doi.org/10.1016/S0140-6736(20)30211-7.

[21] C. Huang, Y. Wang, X. Li, L. Ren, J. Zhao, Y. Hu, L. Zhang, G. Fan, J. Xu, X. Gu, Z. Cheng, T. Yu, J. Xia, Y. Wei, W. Wu, X. Xie, W. Yin, H. Li, M. Liu, Y. Xiao, H. Gao, L. Guo, J. Xie, G. Wang, R. Jiang, Z. Gao, Q. Jin, J. Wang, B. Cao, Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China, Lancet 395 (2020) 497–506, https://doi.org/10.1016/S0140-6736(20)30183-5.

[22] EU Open Data Portal, COVID-19 Coronavirus Data, (2020) (Accessed 22 April 2020), https://data.europa.eu/euodp/en/data/dataset/covid-19-coronavirus-data/resource/55e8f966-d5c8-438e-85bc-c7a5a26f4863.

[23] C. Wang, R. Pan, X. Wan, Y. Tan, L. Xu, R.S. McIntyre, F.N. Choo, B. Tran, R. Ho, V.K. Sharma, C. Ho, A longitudinal study on the mental health of general population

during the COVID-19 epidemic in China, Brain Behav. Immun. (2020), https://doi.org/10.1016/j.bbi.2020.04.028.

[24] Worldometers, COVID-19 Coronavirus Pandemic, (2020) (Accessed 22 April 2020), https://www.worldometers.info/coronavirus/.

[25] Republic of Serbia Open Data Portal, COVID 19 Infection Dataset, (2020) (Accessed 22 April 2020), https://data.gov.rs/sr/datasets/covid-19-zarazheni/.

[26] Republic of Serbia Government, COVID-19 Government Information System of the Republic of Serbia, (2020) (Accessed 22 April 2020), https://covid19.rs.

[27] K. Bandayrel, S. Lapinsky, M. Christian, Information technology systems for critical care triage and medical response during an influenza pandemic: a review of current systems, Disaster Med. Publ. Health Prep. 7 (2013) 287–291, https://doi.org/10.1001/dmp.2011.45.

[28] T.J. Judson, A.Y. Odisho, A.B. Neinstein, J. Chao, A. Williams, C. Miller, T. Moriarty, N. Gleason, G. Intinarelli, R. Gonzales, Rapid design and implementation of an integrated patient self-triage and self-scheduling tool for COVID-19, J. Am. Med. Inform. Assoc. 27 (2020) 860–866, https://doi.org/10.1093/jamia/ocaa051.

[29] K. Prem, Y. Liu, T.W. Russell, A.J. Kucharski, R.M. Eggo, N. Davies, M. Jit, P. Klepac, S. Flasche, S. Clifford, C.A.B. Pearson, J.D. Munday, S. Abbott, H. Gibbs, A. Rosello, B.J. Quilty, T. Jombart, F. Sun, C. Diamond, A. Gimma, K. van Zandvoort, S. Funk, C.I. Jarvis, W.J. Edmunds, N.I. Bosse, J. Hellewell, The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modelling study, Lancet Publ. Health 5 (2020) 261–270, https://doi.org/10.1016/S2468-2667(20)30073-6.

[30] D. Aleksić, P. Rajković, D. Vučković, D. Janković, A. Milenković, Data summarization method for chronic disease tracking, J. Biomed. Inform. 69 (2017) 188–202, https://doi.org/10.1016/j.jbi.2017.04.012.

[31] D. Cooper, K. van Quathem, A. Oberschelp de Meneses, The "Pan-European Privacy Preserving Proximity Tracing Initiative" and Guidance by Supervisory Authorities, (2020).

[32] Apple and Google Detail Bold and Ambitious Plan to Track COVID-19 at Scale, Teetering on a Razor, Smartphone Giants Try to Balance Infection Tracking and Privacy, (2020) (Accessed 14 April 2020), https://arstechnica.com/information-technology/2020/04/apple-and-google-detail-bold-and-ambitious-plan-to-track-covid-19-at-scale/.

[33] L.O. Danquah, N. Hasham, M. MacFarlane, F.E. Conteh, F. Momoh, A.A. Tedesco, A. Jambai, D.A. Ross, H.A. Weiss, Use of a mobile application for Ebola contact tracing and monitoring in northern Sierra Leone: a proof-of-concept study, BMC Infect. Dis. 19 (2019) 810, https://doi.org/10.1186/s12879-019-4354-z.

[34] S. Tian, W. Yang, J.M. le Grange, P. Wang, W. Huang, Z. Ye, Smart healthcare: making medical care more intelligent, Glob. Health J. 3 (2019) 62–65, https://doi.org/10.1016/j.glohj.2019.07.001.

[35] S. Pyne, A.K.S. Vullikanti, Mv. Marathe, Big Data Applications in Health Sciences and Epidemiology, (2015), pp. 171–202, https://doi.org/10.1016/B978-0-444-63492-4.00008-3.

[36] A.A. Adalja, E. Toner, Tv. Inglesby, Priorities for the US health community responding to COVID-19, JAMA 323 (2020) 1343, https://doi.org/10.1001/jama.2020.3413.

[37] A. Milenković, D. Janković, Application of medical information systems in the Republic of Serbia – current status and possible improvements, Information Technologies - Present and Future State, IT'15, XX International Expert Meeting, Faculty of Electrical Engineering, University of Montenegro, Žabljak, Republic of Montenegro, 2015, pp. 108–111.

[38] M.D. Christian, L. Hawryluck, R.S. Wax, T. Cook, N.M. Lazar, M.S. Herridge, M.P. Muller, D.R. Gowans, W. Fortier, F.M. Burkle, Development of a triage protocol for critical care during an influenza pandemic, Can. Med. Assoc. J. 175 (2006) 1377–1381, https://doi.org/10.1503/cmaj.060911.

[39] S.J. Boas, T.F. Bishop, A.M. Ryan, S.C. Shih, L.P. Casalino, Electronic health records and technical assistance to improve quality of primary care: lessons for regional extension centers, Healthcare 2 (2014) 103–106, https://doi.org/10.1016/j.hjdsi.2013.10.003.

[40] A. Milenković, M. Stojković, A. Veljanovski, D. Janković, T. Stanković, L. Stoimenov, Decision making and analysis web tool for MEDIS.NET medical information system, YUINFO 2013, Kopaonik, Serbia, 2014, pp. 507–512.

[41] B. Agarwal, V.E. Balas, L. Jain, R. Poonia, M. Sharma (Eds.), Deep Learning Techniques for Biomedical and Health Informatics, 1st ed., Elsevier, 2020, , https://doi.org/10.1016/C2018-0-04781-7.

[42] Hsiang-Chuan Liu, Shin-Wu Liu, Pei-Chun Chang, Wen-Chun Huang, Chien-Hsiung Liao, A novel classifier for influenza a viruses based on SVM and logistic regression, 2008 International Conference on Wavelet Analysis and Pattern Recognition, IEEE, 2008, pp. 287–291, , https://doi.org/10.1109/ICWAPR.2008.4635791.

[43] B. Dai, R.-C. Chen, S.-Z. Zhu, W.-W. Zhang, Using random forest algorithm for breast cancer diagnosis, 2018 International Symposium on Computer, Consumer and Control (IS3C), IEEE, 2018, pp. 449–452, , https://doi.org/10.1109/IS3C.2018.00119.

[44] A. Đorđević, A. Milenković, D. Janković, L. Stamenković, Optimization of health service schedule, 10th International Conference on Information Society and Technology, Kopaonik, Serbia, 2020 https://www.eventiotic.com/eventiotic/conference/icist2020.

[45] P. Rajković, D. Janković, A. Milenković, Adaption of medical information system's e-learning extension to a simple suggestion tool, 2016 IEEE 18th International Conference on E-Health Networking, Applications and Services, Healthcom 2016 (2016), https://doi.org/10.1109/HealthCom.2016.7749473.

[46] E. Milić, D. Janković, A. Milenković, Health care domain mobile reminder for taking prescribed medications, International Conference on ICT Innovations, Springer, Cham, 2018, pp. 173–181, , https://doi.org/10.1007/978-3-319-68855-8_17.

[47] D. Janković, P. Rajković, T. Stanković, A. Milenković, I. Kocić, Application of medical information systems in education and research in medicine, Acta Med. Median. (2012) 73–80, https://doi.org/10.5633/amm.2012.0113.

[48] Republic of Serbia Government, Republic of Serbia Open Data Portal, (2020) (Accessed 22 April 2020), https://data.gov.rs/en/.

[49] Republic of Serbia Government, "Moj Doktor" IS, (2020) (Accessed 22 April 2020), https://www.mojdoktor.gov.rs/.

[50] I. Markovic, A. Milenkovic, D. Jankovic, An implementation of SMS communication with patients in a medical information system, ICEST 2012 (2012) 178–181.

[51] J.J. Reeves, H.M. Hollandsworth, F.J. Torriani, R. Taplitz, S. Abeles, M. Tai-Seale, M. Millen, B.J. Clay, C.A. Longhurst, Rapid response to COVID-19: health informatics support for outbreak management in an academic health system, J. Am. Med. Inform. Assoc. 27 (2020) 853–859, https://doi.org/10.1093/jamia/ocaa037.

[52] F. Hao, W. Tan, L. Jiang, L. Zhang, X. Zhao, Y. Zou, Y. Hu, X. Luo, X. Jiang, R.S. McIntyre, B. Tran, J. Sun, Z. Zhang, R. Ho, C. Ho, W. Tam, Do psychiatric patients experience more psychiatric symptoms during COVID-19 pandemic and lockdown? A case-control study with service and research implications for immunopsychiatry, Brain Behav. Immun. (2020), https://doi.org/10.1016/j.bbi.2020.04.069.

[53] B.X. Tran, G.T. Vu, C.A. Latkin, H.Q. Pham, H.T. Phan, H.T. Le, R.C.M. Ho, Characterize health and economic vulnerabilities of workers to control the emergence of COVID-19 in an industrial zone in Vietnam, Saf. Sci. 129 (2020) 104811, , https://doi.org/10.1016/j.ssci.2020.104811.

[54] M.W.B. Zhang, R.C.M. Ho, S.E. Cassin, R. Hawa, S. Sockalingam, Online and smartphone based cognitive behavioral therapy for bariatric surgery patients: initial pilot study, Technol. Health Care 23 (2015) 737–744, https://doi.org/10.3233/THC-151026.

[55] M.W. Zhang, P.Y. Chew, L.L. Yeo, R.C. Ho, The untapped potential of smartphone sensors for stroke rehabilitation and after-care, Technol. Health Care 24 (2016) 139–143, https://doi.org/10.3233/THC-151099.

[56] M.W.B. Zhang, S. Chan, O. Wynne, S. Jeong, S. Hunter, A. Wilson, R.C.M. Ho, Conceptualization of an evidence-based smartphone innovation for caregivers and persons living with dementia, Technol. Health Care 24 (2016) 769–773, https://doi.org/10.3233/THC-161165.

[57] A. Rajagopalan, P. Shah, M. Zhang, R. Ho, Digital platforms in the assessment and monitoring of patients with bipolar disorder, Brain Sci. 7 (2017) 150, https://doi.org/10.3390/brainsci7110150.

[58] L. Ferretti, C. Wymant, M. Kendall, L. Zhao, A. Nurtay, L. Abeler-Dörner, M. Parker, D. Bonsall, C. Fraser, Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing, Science 368 (2020) eabb6936, https://doi.org/10.1126/science.abb6936.

[59] S.M. Kissler, C. Tedijanto, E. Goldstein, Y.H. Grad, M. Lipsitch, Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period, Science 368 (2020) 860–868, https://doi.org/10.1126/science.abb5793.