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COVID-19 pandemic in Bosnia and Herzegovina: March – June 2020: Epidemic Location Intelligence System (ELIS)

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АКАДЕМИЈА НАУКА И УМЈЕТНОСТИ БОСНЕ И ХЕРЦЕГОВИНЕ
ACADEMY OF SCIENCES AND ARTS OF BOSNIA AND HERZEGOVINA

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Epidemiološki lokacijsko-obavještajni sistem (ELIS)

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Urednik
Miloš Trifković

SARAJEVO, 2020.



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Epidemic Location Intelligence System (ELIS)

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FOREWORD

At the end of 2019 the world became aware of the existence of a new virus stemming from the *Coronaviridae* family and causing a specific disease – COVID-19. In less than three months, the virus and its consequences, developed from being a local public health problem in China to a daunting global problem we all had to face. On March 11, 2020 the World Health Organization (WHO) declared a pandemic of COVID-19.

On the international scale, even in Bosnia and Herzegovina (BiH), the response of the professionals and scientists has been rapid, although not always consistently efficient enough. Despite the selfless cooperation of scientists and practitioners worldwide, countries with developed economies, good public health and a strong scientific system have had the advantage in the fight against the disease over developing countries. Despite the fact that by these criteria BiH is not one of the most resilient countries, so far, its response to the pandemic has seemed to be satisfactory.

The Academy of Sciences and Arts of Bosnia and Herzegovina (ANUBiH) was one of the first institutions of the science system to respond to the pandemic. On the initiative and under the leadership of academician Mirsada Hukić, on March 22, 2020 the development of the project "Epidemic Location Intelligence System (ELIS)" and its Geoportal began on a voluntary basis, with the task of permanently monitoring the spread of COVID-19. Theoretical and professional parts of the project in the areas of medicine, public health and informatics were completed by April 2, 2020. Thanks to the support to the project by the Chairman of the Presidency of Bosnia and Herzegovina, Mr. Šefik Džaferović, the expert system received additional hardware support and was filled in time with data from across the country. This enabled the system to become operational as early as on April 8, 2020. The results of all these efforts are visible in this publication.

Initially, the ELIS project was important for the epidemiological and public health area. The abundance of collected data and obtained virus samples enabled the extension of the project idea to the sequencing of viruses found in BiH and their typology. The transition of research to the clinical aspects of COVID-19 is the next

phase in the development of the ELIS project. ANUBiH has already started the work on examining the economic and pedagogical consequences of COVID-19 in order to look at this medical phenomenon in the broadest possible context.

All the results of ANUBiH in response to the epidemic challenges of COVID-19 are achieved due to the synergistic action of numerous individuals and institutions in different fields of science and public health in cooperation with government. Therefore, I believe that the ELIS project has shown the way to go in solving the burning problems of our society which we will encounter in the future.

*President of ANUBiH
Academician Miloš Trifković*

1. INTRODUCTION

Infections are the main cause of disease and human death worldwide. It is estimated that they cause nearly 17 million deaths and make 33% of all the deceased in the world every year. At the same time, infections caused by new pathogens are becoming a leading health problem of the 21st century. New diseases are caused by new pathogenic agents or already known agents that emerge in a new area or cause disease in a new type of host. After many years of absence, new/old diseases reappear in the certain area. As a rule, new diseases are caused by highly pathogenic microorganisms, usually resistant to medications. A large number of these microorganisms are listed as the ones that can be used in bioterrorism.

Almost 75% of new diseases are zoonotic, diseases transferred from animals to humans, directly or via vectors (mosquitoes, ticks). The main reason for the emergence of zoonotic new pathogens and dramatic increase in the number of infectious diseases caused by them is still unknown. A correlation between their emergence and great changes in nature is noted.¹ Conditions in which microorganisms mutate and become human pathogens are made by complex interactions of social and demographic changes in a population and changes in the natural environment. New technologies enable the change in microorganism's genome. Nowadays we are encountering numerous natural agents, some with higher virulence than they exhibited in the past. We've further encountered existing synthesized agents as well as newly designed and synthesized agents. All factors that contribute to the growth of natural reserves of pathogens are directly related to the appearance of human diseases.

Due to the enormous damage to human health and the world economy caused by the COVID-19 pandemics, it has unsurprisingly attracted an immense interest of medical, economic and political authorities and institutions. Patients with viral pneumonia caused by unidentified microbial agent have been reported in the Chinese city of Wuhan (province Hubei) at the end of December 2019.

The coronavirus disease 2019 (COVID-19) had spread rapidly over many continents and a great number of countries, and it became the reason for the World Health Organization to declare this disease a pandemic on March 11, 2020.²

Between December 31, 2019 and June 17, 2020, there were over 8 million cases of COVID-19 reported worldwide (in accordance with applied definitions of cases and testing strategies in affected countries), including 435.000 reported deaths.³ At the same time in Bosnia and Herzegovina 3.141 COVID-19 infections were confirmed, that included 2.197 recovered cases and 168 deaths.⁴

Coronavirus / SARS-CoV-2

Coronaviruses have been known as human pathogens since 1965. Thus far, 7 types of coronaviruses infectious to humans have been identified. Among them, the common human types 229E, NL63, OC43 and HKU1; and novel coronavirus types MERS-CoV, SARS-CoV and SARS-CoV-2.

SARS-COV-2 is spherical, enveloped RNA virus 80-160 nm in size. Its genome is non-segmented single-stranded RNA (ss-RNA) of 29903 bp. The structural proteins of the virus include two glycoproteins and one phosphoprotein. At the surface of its spiral nucleocapsid 20nm long glycoprotein spikes (peplomers) are located in the shape of a mace or petals bearing resemblance to the corona of the Sun. This glycoprotein is labeled S and it entails two functional subunits. The first one is responsible for binding to cell receptors (S1 subunit), while the other one facilitates the fusion of the cell and the viral membrane (S2 subunit).

On January 17, 2020, Chinese scientists delivered full genome sequences of Wuhan China SARS-COV-2 to the NCBI database, with ID NC 045512.

Based on phylogenetic analysis and taxonomy the Coronavirus Research Group (CSG) of the International Committee on Taxonomy of Virus concluded that the new virus was from the SARS-CoV (Severe Acute Respiratory Syndrome Coronavirus) family and could be considered to be a new beta coronavirus that infected humans. The virus nomenclature changed several times in the beginning and its final name, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), was accepted on February 11, 2020.

The similarity analysis of the first few strains of virus in China resulted in 99.98% similarities. From January 17 to June 17, 2020 the virus showed its genetic variability. Worldwide more than 40 703 SARS-CoV-2 full genomes have been sequenced thus far. All of them have been classified in seven groups according to their similarities.⁵

Virus ecology and infection transfer path

Coronaviruses are widespread in nature. They cause persistent infections in some animal species (e.g. bats, mice, etc.) and can cause a disease in humans and in wild and farm animals (poultry, cattle, pets). Different types of viruses bind to their hosts and there they evolve. Coronavirus transmission between species happens in nature, but it is a very complex process and it is “risky” for the virus, as well as for the host. The new coronavirus (SARS, MERS, COVID-19) pandemic outbreaks accentuate the ne-

cessity for further research on the coronavirus ecology, especially the role of bats and wild animals as virus reservoirs and the source of infection for people.

Scientific teams all over the world agree that SARS-CoV-2 is created by a natural evolutionary process and that it is not a product of genetic engineering and bioterrorist activities. Currently, phylogenetic analysis suggests that bats are native hosts of the virus and that a small mammal, pangolin, acted as a transition host that spread the infection to humans. Ecology, evolution, adaptability and spreading of this virus are still not fully elucidated and require additional fundamental research.

Regardless of the original and transitional host, SARS-CoV-2 acquired the capability to transfer from an infected to a healthy person via large drops in aerosol, direct contact from person to person, or through a contact with contaminated hands and surfaces. Based on available studies, asymptomatic spread is probable, which presents a large problem in efforts to curtail the epidemic.

Disease pathogenesis

Viral replication initially takes place in the epithelial cells of the upper respiratory tract. The human cell receptor for SARS-CoV-2 is angiotensin converting enzyme 2 (ACE2). Through the C glycoprotein extensions located in the outer viral envelope, the virus binds to ACE2, and as a result of their interaction, a fusion of the viral and cell membranes occurs and the virus enters the cell (Song, W. et al., 2018).⁶ The ACE2 receptor is present in the ciliary epithelial cells of the upper and lower airways, as well as in type II pneumocytes, which are located in the alveoli of the lungs. Upon entering the cell, SARS-CoV-2 infects it and virus multiplication occurs. At the same time, a non-specific and specific immune response is triggered, which in a high percentage prevents the development of an infection or the development of a severe form of the disease.⁷

For reasons that are not entirely clear, some people have a dysfunctional immune system that inadequately responds to the SARS-CoV-2 infection. Such immunopathological reactions most often occur in the elderly, diabetics and people with diseases of the cardiovascular system.

They have an uncontrolled immune response, which causes the overproduction of immune cells and their signaling molecules, and leads to a “cytokine storm” that is often associated with a flood of immune cells in the lungs. As a result of their activity, severe inflammatory processes of the airways and lungs can occur, as well as loss of their function. Excessive inflammatory response, platelet activation, endothelial dysfunction, and stasis may lead to the development of thrombotic disease, e.g. hematologic abnormalities such as disseminated intravascular coagulation.

The virus can enter the bloodstream, cause sepsis, and carry blood to distant organs where it attacks ACE2 receptors and leads to inflammatory processes in them. Many types of human cells express ACE2 receptors and target viruses, including the heart, blood vessel endothelial cells, kidneys, intestines, and brain tissue.

Particular importance is attached to determining the impact of neurological tissue damage, morbidity and mortality caused by SARS-CoV-2 infection. It is increasingly certain that severe clinical presentations of COVID-19 lead to the infection of the brain and nerves, which can result in brain swelling, pressure on the brain stem, difficulty in involuntary breathing, loss of smell and taste⁸, etc.

Clinical picture of COVID-19

The incubation period, the time between exposure to the virus and the appearance of first signs and symptoms of the disease is 2 to 14 days, or an average of 5 days.^{9,10} Most COVID-19 infections are asymptomatic and mild. However, about 15-20% of the infected people develop a very severe and even deadly disease. Signs and symptoms of the disease vary in their prevalence and intensity. Common symptoms of COVID-19 are fever, chills, weakness, cough, heavy breathing and shortness of breath. A very specific sign of the disease is loss of sense of smell and altered sense of taste. Some of the patients have headache, muscle aches, pharyngitis, anorexia, nausea, vomiting, diarrhea, abdominal pain, or abdominal discomfort. Pneumonia, hypoxia and dyspnea occur in severely ill patients, and shock, respiratory failure and multiorgan dysfunction occur in critical patients.

The course and outcome of the disease depend on a number of factors related to the infected person. It has been observed that the elderly are at high risk of developing a serious illness. The severity of the clinical picture of the disease is related to the existence of other diseases, including immune system disease, diabetes, hypertension, cardiovascular disease, chronic lung and kidney disease, liver disease, malignant disease and severe obesity.^{11,12} Blood type A is thought to be a potential risk factor for respiratory failure, and the role of some genetic mutations that could be risk factors is considered.¹³

In general, children suffer from a milder form of COVID-19. In very rare cases, children have been observed to develop a multisystem immune response to SARS-CoV-2 infection, which includes vasculitis affecting the coronary arteries, prolonged fever, rash, conjunctivitis, mucositis, and lymphadenopathy, and corresponds to the characteristics of Kawasaki syndrome.¹⁴

COVID-19 therapy is given according to the professional assessment of a clinician in charge, the availability of drugs taking into account comorbidities, interactions with other drugs and possible side effects.¹⁵

Supportive/symptomatic therapy is currently the method of treatment, while new antiviral drugs are being tested. It includes rehydration with caution against the possibility of volume loading; urgent oxygen supply when needed; use of antibiotics in case of bacterial superinfection; prophylaxis of thromboembolic incident with low molecular weight heparin at usual doses, and anti-inflammatory drugs (dexamethasone).

Remdesivir, favilavir, lopinavir/ritonavir are currently recommended as antiviral therapies, while chloroquine, which was thought to be useful in the treatment of patients with COVID-19, has been declared useless and harmful to patients.¹⁶

COVID-19 diagnostics

The diagnostic procedure of COVID-19 is complex and includes medical history, epidemiological history, clinical examination, laboratory testing and imaging tests.¹⁷

EUROPEAN CENTER FOR DISEASE PREVENTION AND CONTROL (ECDC), 29.05.2020.

Case definition for coronavirus disease 2019 (COVID-19)

Clinical criteria

Any person with at least one of the following symptoms:

- cough,
- fever,
- shortness of breath,
- sudden attack of complete loss of smell (anosmia), disturbed sense of taste (dysgeusia) or feeling of unpleasant taste (ageusia).

Diagnostic recording

Radiological evidence showing COVID-compatible lung lesions;

Laboratory criterion

Detection of SARS-CoV-2 nucleic acid in a clinical specimen;

Epidemiological criteria

At least one of the following two epidemiological links:

- close contact with a confirmed case of COVID-19 in the 14 days before the onset of symptoms,
- stay with a permanent resident or employee in the 14 days before the onset of symptoms, in a residential facility for vulnerable people, where it has been confirmed that a COVID-19 infection is ongoing.

Case classification

Possible case:

- *Any person who meets the clinical criteria;*

Probable case:

- *Any person who meets the clinical criteria with an epidemiological link or*
- *Any person who meets the diagnostic criteria;*

Confirmed case:

- *Any person who meets the laboratory criteria.*

Based on the clinical examination and epidemiological anamnesis, the clinician can suspect COVID-19 infection. Patients with suspected COVID-19 should be reported immediately to an appropriate epidemiological service. The criteria for re-

porting: the patient is with fever, has symptoms of lower respiratory disease, has complete or partial loss of sense of smell (anosmia), was traveling or staying in an area with local transmission of COVID-19 in the past 14 days, or was in contact with a person suspected of having COVID-19, or a patient with laboratory-confirmed COVID-19. In case the testing capacities are sufficient, laboratory testing of all individuals with acute respiratory syndrome and their contacts is recommended. If this is not possible due to lack of material and human resources, then targeted testing is recommended given the case definition¹⁸.

Laboratory testing on COVID-19

The clinical diagnosis of COVID-19 must be confirmed in a laboratory, i.e. by proving the presence of SARS-CoV-2. Testing should be undertaken as early as possible, as it is crucial for the treatment of the disease, but also for the prevention of further spread of the infection. Nucleic acid amplification tests (NAAT) are the gold standard for the diagnosis of COVID-19. Molecular tests RT-qPCR (reverse transcriptase – quantitative polymerase chain reaction) of various manufacturers are in use, which can prove the N, E, S and RdRP genes of the virus. Positive results must be demonstrated by a positive finding of at least two target viral genes, at least one of which must be specific for the new coronavirus (SARS-CoV-2). SARS-CoV-2 infection does not rule out a negative finding. The finding can be a false negative for multiple reasons: poor sample quality, sampling too early or too late after the infection, inadequate storage and transport of the sample, virus mutations, and errors in the test. Testing should be repeated in case of a negative finding in patients with a high index of suspected COVID-19 disease.¹⁹

Basic samples for the analysis are nasopharyngeal and/or oropharyngeal swab and sputum, whereas endotracheal aspirate and bronchoalveolar lavage are samples of hospitalized patients. It is necessary that samples be collected into a transportation solution (cca. 2 ml of Hanks solution or saline) and delivered to the laboratory as soon as possible. Until being transported, samples are kept in a fridge at +4°C.

Molecular diagnosis is expensive and requires highly equipped laboratories. In countries with limited material resources, the introduction of tests for the assessment of the antigen of the virus SARS-CoV-2 in respiratory samples, would be very useful. For now, a limited number of tests based on that principle can be found, but intensive work is being done on their development.

Serological tests which detect specific antibodies for SARS CoV-2 have very limited application in clinical practice because they become positive only after 7 – 10 days from the onset of symptoms. These tests are used for retrospective diagnosis. For that purpose, paired serum samples (in acute and in convalescent phase) are taken from the patients in order to analyze immunoglobulin classes and to track antibody titer dynamics. The selection of the testing method (molecular or serological diagnostics) depends on the aim: setting the diagnosis, finding a source of the infection, serological surveillance, the selection of a plasma donor for drug preparation etc. Methods can and should be combined in order to achieve all the goals.²⁰

X-ray and CT scans of the lungs

In patients with manifest COVID-19 disease CT scans of the lungs show multifocal spotted shadows, appearing as “milk glass”, which are located in the peripheral parts of the lungs, the subpleural area and in both lower lobes. The disease progression occurs after 5 to 10 days, whereby the size and density of the lesions increase, and soon the functional lung tissue is lost. Lungs become opaque, known also as “white lungs”.²¹

Epidemiological surveillance

Epidemiological surveillance is a continuous systematic collection, analysis and interpretation of health data, bearing in mind their temporal representation and spatial distribution. The data collected is essential for the planning, implementation and evaluation of public health practices. The final link in the surveillance chain is the application of this data in order to prevent and control the disease. The monitoring system implies the existence of functional capacities for the data collection, analysis and submission to public health programs.²²

By the conclusion of the Government of the Federation of BiH and the Government of the Republika Srpska, COVID-19 was declared a contagious disease whose prevention and suppression are of interest to Bosnia and Herzegovina. In accordance with the emergency situation, and in order to prevent the spread of the COVID-19 disease, a very dynamic normative activity is in force in Bosnia and Herzegovina. Following the organizational structure of Bosnia and Herzegovina, a crisis headquarters was formed at the level of entities and cantons, with the task of monitoring the epidemiological situation and adopting appropriate anti-epidemic measures. Many regulations, which regulate the new situation, are published on a daily basis in the form of decrees, decisions, and orders.²³

The first line of defense against the spread of the epidemic is primary health care (PHC) with its family medicine teams, epidemiological service and COVID clinics. Each of the family medicine teams fills out a questionnaire for patients suspected of COVID-19 and directs them to specialists at the secondary or tertiary level of health care according to indications. In COVID clinics, which operate 24 hours a day, COVID teams are organized (doctor of medicine and 2 medical technicians), and receive phone calls (which are registered and recorded), provide consultations, propose self-isolation, indicate testing and schedule medical examinations (in the clinic or home visits), and according to the severity of the clinical picture indicate transport to hospital.

Epidemiological surveillance of close contacts is carried out by the Public Health Institutes (PHI) that work closely with Health Centers (HC), family medicine teams, and COVID clinic teams in indicating testing. They prepare epidemiological reports for the imposition of home isolation measures, monitor the epidemiological status of individuals in self-isolation and propose the termination of home isolation and self-isolation measures.

Patients are treated in specially equipped COVID hospitals. All signs and symptoms of the disease, diagnostic and therapeutic measures taken are recorded in the medical history and temperature list. For now, questionnaires intended for hospital epidemiological surveillance are not filled out. The introduction of hospital epidemiological surveillance would significantly contribute to the introduction of a new virus and a new disease, as well as in making the best decisions for the treatment of patients.

Laboratories in Bosnia and Herzegovina follow national regulations on the reporting of infectious diseases and new pathogens. Suspicious cases should be reported to public health authorities when the sample is sent to the laboratory and before any test is conducted. All test results, whether positive or negative, should also be reported immediately to public health authorities. The reporting path in Bosnia and Herzegovina is as follows: referent laboratory for the diagnostics of SARS-CoV-2; Cantonal Institute of Public Health; Federal Institute of Public Health in Bosnia and Herzegovina; Institute of Public Health of Republic of Srpska; Department of Health of Brčko District; Health Sector of the Ministry of Civil Affairs of Bosnia and Herzegovina; European Surveillance System (TESSy).

The present system has many shortcomings: a different scope of epidemiological surveillance in different parts of the country, there is no national point for collecting and processing epidemiological information uniformly from different parts of the country, and finally the shortcoming of having disparate preventive measures in different parts of the country. Furthermore, integrated biostatistical analyses of the spread rate in space and time on country level have not been done. Due to such fragmentation of the epidemiological surveillance system, the effectiveness of preventive measures, and short-term and long-term forecasts of the epidemic development, are left out completely. There is no centralized or harmonized reporting to health institutions, to different levels of government and to citizens in Bosnia and Herzegovina. Without accurate and timely information, making good decisions about preventing and controlling epidemics is not possible.

2. VIROLOGICAL RESEARCH

The Committee for Microbiology and related disciplines of ANUBIH is active in the field of virology research in Bosnia and Herzegovina. With the purpose of sequencing the SARS CoV-2 viral genome we conducted research in cooperation with the Laboratory for Molecular Genetics and Forensic Research of the Faculty of Veterinary Medicine, University of Sarajevo (VFUNSA).

Samples for virus isolation and sequencing of the viral genome

Samples for virus isolation and sequencing of the viral genome are provided by microbiologists from accredited virology laboratories in Bosnia and Herzegovina. Special attention was dedicated to the quality of delivered samples, both for the needs of SARS CoV-2 detection and for virus isolation. A total of 41 samples were submitted to the Laboratory for Molecular Genetics and Forensic Examinations (VFUNSA), of which 20 nasopharyngeal swabs in viral transport medium (VTM) or PBS (Phosphate-buffered saline), and 21 samples of extracted nucleic acids.

Virus isolation

Prior to isolation, nucleic acids were extracted from clinical samples of nasopharyngeal swabs (20 in total), followed by the detection of SARS-CoV-2 using real-time PCR (RT-PCR) diagnostic method according to the HKU protocol, which was recommended by the World Health Organization (WHO).

Samples whose Ct values (real-time detection threshold of RT-PCR) were below 30, and which were sufficient in volume (minimum 400 µL), were considered for the isolation attempt via cell cultures. In this regard, a total of 12 samples were used for cell culture inoculation.

Due to the fact that after successful infection and replication in cells, SARS CoV-2 is released by exocytic secretory pathway, which ultimately leads to cell death, the effect of inoculation of test samples was accompanied by the appearance of cytopathogenic effect – CPE (cell death in culture in case of successful infection – replication).

Inoculated cell cultures were microscopically monitored daily for the presence of CPE, which was observed on the eighth day from the day of the first inoculation. The specificity of CPE was confirmed by the extraction of nucleic acids from the supernatant of infected cell cultures, both in terms of specificity (positive real-time PCR) and in terms of increasing virus titer during inoculation (lower Ct values correlate with incubation length).

As described above, the virus was successfully isolated from three samples. How many virus strains of SARS CoV-2 in Bosnia and Herzegovina are in circulation can only be ascertained after extensive additional research.

Sequencing of the viral genome from clinical samples

For the purpose of sequencing the complete viral genome from clinical samples, both nucleic acid extracts (transported and delivered to the laboratory in an appropriate container), and extracts of samples delivered to the laboratory as native (swabs in VTM or PBS) were used. Due to limited financial resources and the initial moratorium on imports of medical devices manufactured in the EU, it was not possible to quickly procure diagnostic reagents for sequencing the complete viral genome, so two samples with Ct values below 24 were used. This ultimately resulted in the generation of complete sequences, which were stored in the GISAID international gene database under access numbers, as follows: EPI_ISL_462753 (name of the virus in GISAID database-hCoV-19/Bosnia-and-Herzegovina/01-Livno/2020) and EPI_ISL_462990 (name of the virus in GISAID database-hCoV-19/Bosnia and Herzegovina/02-Banja Luka/2020). As such, the sequences are publicly available to the widest scientific research community.

The generated sequences will be used in the forthcoming period to shed light on a number of issues, such as:

- a) directions of imported infection in B&H;
- b) accuracy of the used diagnostic methods, primarily those based on real-time RT-PCR technique in order to improve the early detection system;
- c) identifying virus mutations that could, at least in part, elucidate reasons for the difference in disease outcome caused by the virus in B&H and the world;
- d) designing a more efficient system/model for early detection of new cases of infection, and targeted and timely actions to prevent the spread of the virus.

3. EPIDEMIOLOGICAL LOCATION INTELLIGENCE SYSTEM (ELIS)

Before we started with the inception of ELIS we conducted a survey of existing ICT based solutions for epidemiological tracking and surveillance in Bosnia and Herzegovina. We were not successful in finding a country wide, integrated system, that allows a uniform, and standardized access to actionable information for health care institutions engaged in tracking and curtailing public health issues related to the COVID-19 epidemic. Such information is necessary for decision-makers to implement various measures aimed at controlling the epidemic (procurement of protective equipment, tests, control of population movements, economic measures, etc.). The expert system for monitoring and preventing the spread of the COVID-19 virus – Epidemiological Location Intelligence System, which was created as a research project of ANUBIH, is unique in Bosnia and Herzegovina and the wider region, and is original work. It is designed for scientists, experts and professionals in the field of health care to use. Experts from other areas relevant for monitoring and research of epidemic phenomena would, of course, also be able to draw important conclusions based on information provided by ELIS.

The aim of the project is to provide information relevant to epidemiological surveillance in Bosnia and Herzegovina, as well as a scientific research database for other complementary and interdisciplinary projects.

The subject of the research is the spatial and temporal monitoring of the spread of the COVID-19 virus in Bosnia and Herzegovina through:

- the collection of epidemiological and other data important for monitoring the outbreak of the epidemic and its spread,
- biostatistical analysis of the virus spread rate and spatio-temporal distribution of infectious and other diseases,
- ad hoc analysis and evaluation of the epidemic surveillance system in place, as well as recommendations for its improvement,

- briefing, reporting and informing about the epidemic situation and evaluating the efficacy of restrictive social measures in order to make more sustainable decisions,
- evaluation of epidemic data through active serological surveillance and
- centralization and exchange of biostatistical and other data for research projects.

For this purpose, information and communication technology (ICT) backend infrastructure, a web platform, and data with implemented epidemiological models relevant for monitoring the spread of the disease are put in place. As part of the system, a geoportal for geovisualization, communication, data entry and research (ELIS geoportal) has been developed.

As a step towards more consistency and comprehensiveness of the collected epidemiological data, modifications of the existing questionnaires were recommended. If adopted, these would allow for a uniform and systematic data collection. Also, a questionnaire for hospital epidemiological surveillance was proposed (Appendix 1).

Epidemic location intelligence information system

The Epidemic Location Intelligence System (ELIS) is an expert information system for analyzing epidemic data and reporting. It incorporates tools for communication, analysis and reporting, that rely on the robust ICT infrastructure in the background. The system is based on modern design principles and service – oriented architecture, so it allows complete separation of backend and frontend as shown in Figure 3.1.

Frontend is a Java script web application that communicates with web services using AJAX and allows to connect different mapping libraries. The frontend is based on the ReactJS library and the Redux architecture, which is a specific implementation of the Flux architecture. Backend is a set of web services developed in Java including services for HTTP-Proxy, storage of unstructured resources, and security services. It is able to configure authentication using internal or external service, and flexible authorization policies for access to services and resources.

Based on this architecture and the concept of Web 2.0, the system provides free classification of information, responsive interface with dynamic content, user participation in terms of changing data and interface, and Software as a Service based on APIs. It includes standard analytical tools such as interactive maps, control panels, various diagrams, etc. User interface, as its client segment, allows different types of users to work easily, especially the non-IT-expert users. Each logged-in user is assigned with appropriate services (maps, dashboards, database schemas).

The portal provides links to other websites including various security measures and access rights to the portal or parts of it. It can be personalized to fit the needs of the user in terms of functionality and appearance. Its development aims to promote the interoperability of data and services, which is achieved through the acceptance

and implementation of the standards. Interoperability is largely achieved through standardized geoportal architecture. Users are separated into two main categories – GIS and epidemic data administrators (Figure 3. 2).

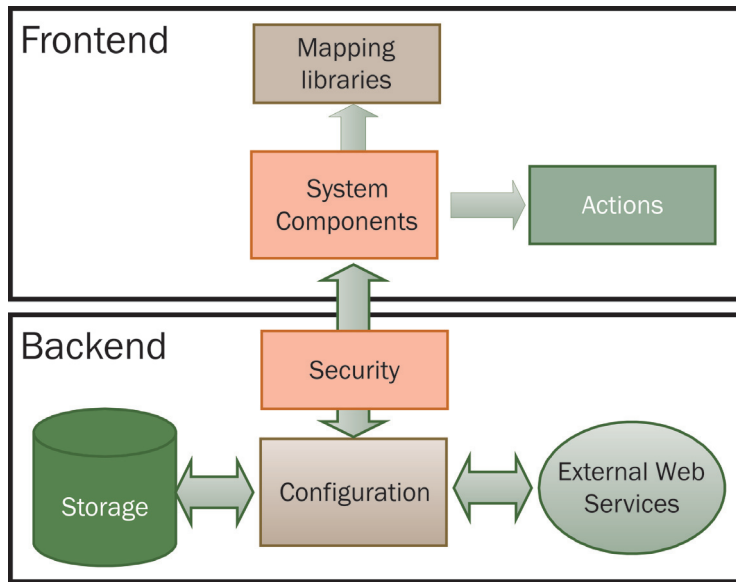


Figure 3.1. Architecture of Epidemic Location Intelligence System (ELIS)

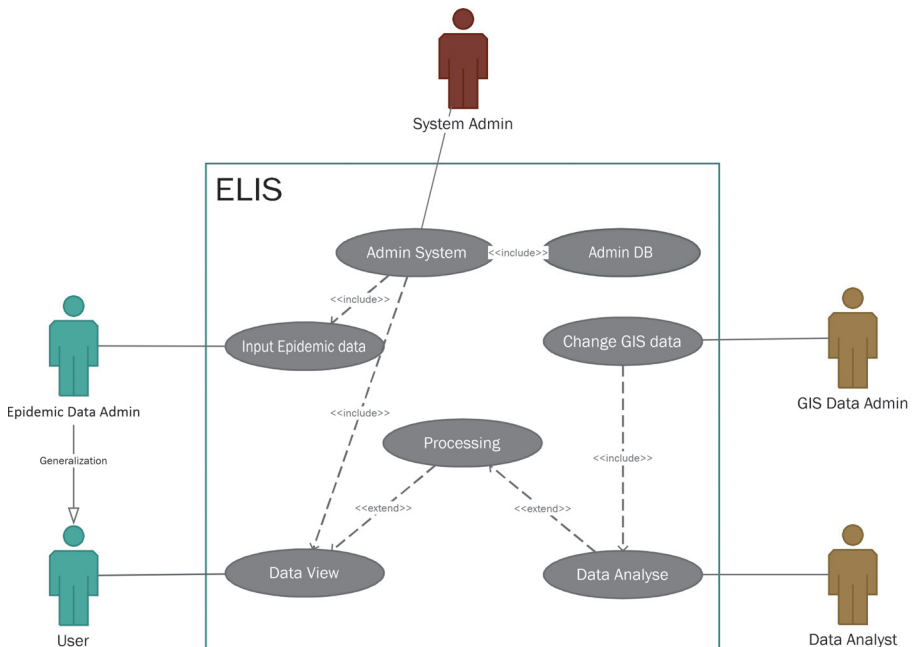


Figure 3.2. Use Case of Epidemic Location Intelligence System (ELIS)

Users of the system are as following:

- From Public Health Institutes
 - Epidemic Data Admin, who input epidemic data and users, who review data
- From Academy of Science and Arts:
 - System Admin, who administrate database, users and system interface
 - GIS Data Admin, who administrate spatial data
 - Data Analyst, who performs analytics of data (geospatial, SIR model, Epi curves)

4. MATERIALS AND METHODS FOR SPATIO-TEMPORAL ANALYSIS OF COVID-19 SPREAD

According to the constitutional solutions, the public health system in Bosnia and Herzegovina is regulated in accordance with the administrative authorities of the entities of the Federation of Bosnia and Herzegovina (FBiH), Republika Srpska (RS), Brčko District and cantons in FBiH. The fragmentation of the system imposes the use of different health information systems whose modules related to health insurance, medical services, as well as epidemic surveillance are often not interconnected. Due to their heterogeneity and the application of different administrative protocols for the use of data, it was necessary to establish a special mechanism for collecting epidemic data from individual local public health institutions and their placing in the Epidemic Location-Intelligence System (ELIS).²⁴ In addition to these sources, other available sources were used, such as web portals of public health and government institutions with official announcements about the epidemic situation²⁵ and announcements from clinical centers and microbiological laboratories. Continuously collected data from

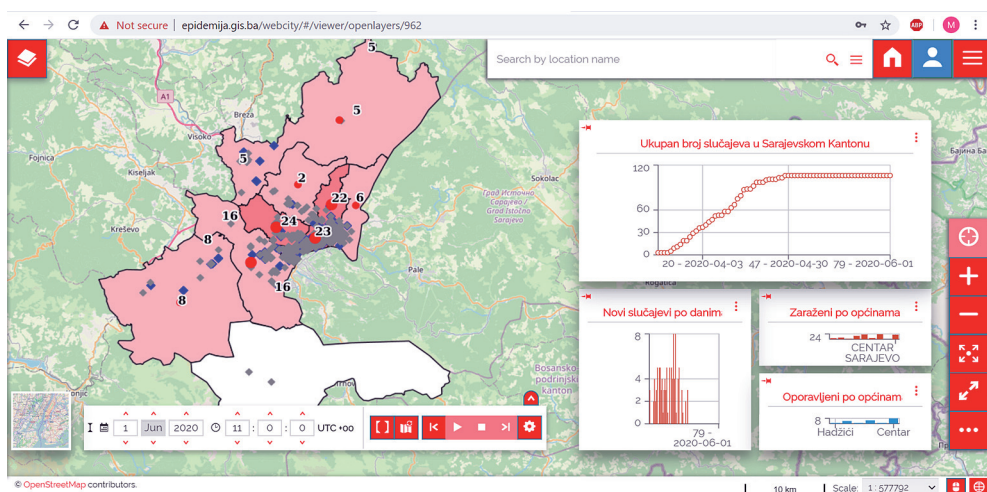


Figure 4.1. Interactive forms of visualization of epidemic data in the ELIS geoportal

these sources, combined with geographical, demographic and other data, was processed using the selected analytical methodology, and the results were arranged in the ELIS geoportal in the form of diagrams, attribute tables, interactive maps and animations (Figure 4.1).

Using the rich possibilities of organization and ways of interactive presentation of data through the geoportal²⁶, a detailed overview of key indicators related to the dynamics of spatial and temporal spread of infection is provided.

In addition to the techniques of geospatial analysis and the presentation of epidemiological data, various methods were used to monitor and predict the spread of infection, and to evaluate the effectiveness of control measures taken to stop the epidemic.

In accordance with the availability of epidemic data sets and clinical information, several methods and techniques have been selected to identify, analyse and predict the spread of infection,²⁷ including compartmental epidemic models²⁸, epi-curve diagrams, instantaneous reproduction number R_t ^{29,30}, descriptive statistics and interactive choropleth maps for various levels of administrative units.³¹ These methods were used individually to display one or more epidemiological parameters or in combination, depending on the context.

Monitoring and prediction of the spread of COVID-19 virus

The available data for monitoring the spread of infection consisted of daily and cumulative values for the infected, tested, recovered and deceased individuals. The only demographic attributes available were sex and age. Important data for fitting the epidemiological models and estimating parameters such as a list of symptoms, date of their reporting and onset, infected persons' contacts in the last 14 days as well as place of residence and other relevant information were partially available.³² These attribute values were supplemented with demographic data related to the representation of age and gender groups, and household and social category statistics used for quantification and comparison analysis results by various statistical parameters.

The disease dynamics of the population is described by the elementary compartmental SIR model (Susceptible; Infectious; Resistant) through the daily dynamics in the number of individuals transitioning between three epidemiological categories (susceptible, infectious and resistant). Their total value is constant and corresponds to the current number or some expected number. To determine this number, two possible scenarios with optimistic and pessimistic outcome of the epidemic were applied when modelling the dynamics of the disease.

The optimistic scenario implies that the final number of patients will remain at the current level. The pessimistic scenario corresponds to the expectation that the number of patients will grow to a level proportional to the outcome in a country with a high incidence rate (e.g. in Italy and Spain that have been severely affected). In this way, the current epidemic situation and the magnitude of the spread of infection could be compared and evaluated for individual environments.

Parameters governing the infection spread as modeled by the SIR model³³ (β - probability of contact between infected and susceptible, γ - probability of recovery of the infected person, and the total number of susceptible people assumed under the optimistic scenario) were estimated using iterative approach of minimizing the sum of squares of the differences between the cumulative number of cases and the number of cases predicted by the model.

Based on these values, the average basic reproductive number R and the threshold (degree) of immunization of the population (HIT number) were determined.²⁹ A calibrated SIR model was used to predict the dynamics of the infection spread (Figure 4.2).

Reports with these epidemiological parameters, descriptive statistics with the degree of the disease by age and sex groups, and calibrated models of the disease dynamics were periodically generated for individual administrative units and published via ELIS geoportal.

Furthermore, in order to identify the effectiveness of individual control measures to stop the spread of infection, diagrams of epidemic curves and the instantaneous reproductive number R_t were used.

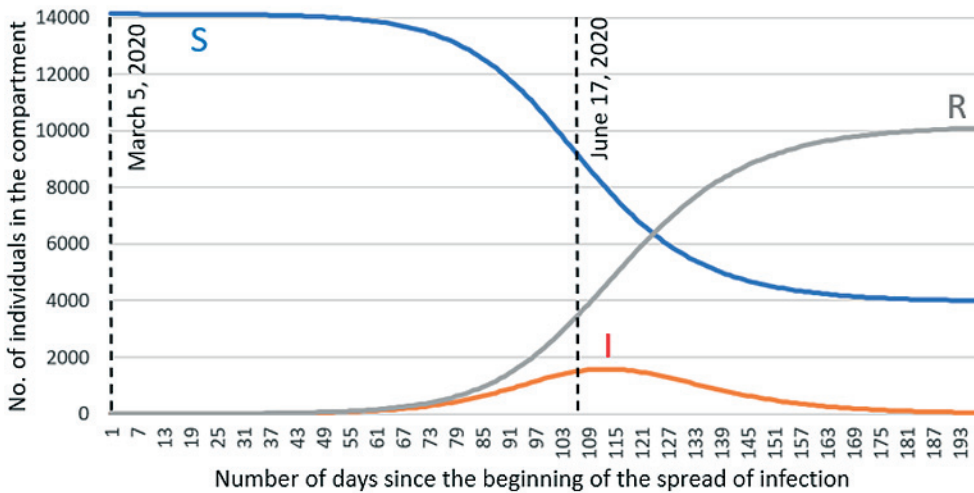


Figure 4.2. SIR (Susceptible – Infectious – Resistant) model of disease dynamics for Bosnia and Herzegovina (pessimistic scenario) developed for the period from March 5 to June 17, 2020.

Instantaneous reproductive number R_t

The instantaneous reproductive number R_t was used to evaluate the effectiveness of the control measures taken to stop the epidemic. By its definition, it represents the time-dependent expected number of secondary infections caused by each individual primary infected case. Its value was estimated using data on the number of new cases observed consecutively during the epidemic over a series of time intervals. Its calcu-

lation made it possible to assess the impact of restrictive measures on the behavior of the population and to reduce or stop the transmission of the infection.³⁴ R_t values below 1 indicate a reduction and cessation of the infection spread, a value equal to 1 represents linear growth, and above 1 means infection transitions to exponential growth spread and further escalation (Figure 4.3). To estimate R_t we used the R statistical software package *EpiEstim*.³⁰ To compensate for partially available information about the time since symptom onset for each person, we relied on the estimate from the staff in the field. Distributional characteristics of the serial interval (necessary for appropriate use of *EpiEstim*) were taken from Ganyani et al.³⁵ The incubation period distribution was taken from Backer et al.⁹ The estimation of R_t was done after the reporting dates received from different public health institutions were set back for the observed (in case it was not reported, estimated) symptomatic period and unobserved incubation period. Subsequently, we used the methodology implemented in estimate R function of the package *EpiEstim* to estimate R_t using a window of one week in the past (see Cori et al.).³⁰

Mapping the spread of COVID-19 virus

Quantitative epidemic data related to the daily increment or the cumulative number of tested and infected cases in individual geographical regions are classified by rank and presented using choropleth maps according to the selected color classification scheme. Furthermore, for the spatial-temporal visualization of the total number of infected people and the display of their average number per 100,000 inhabitants at ten-

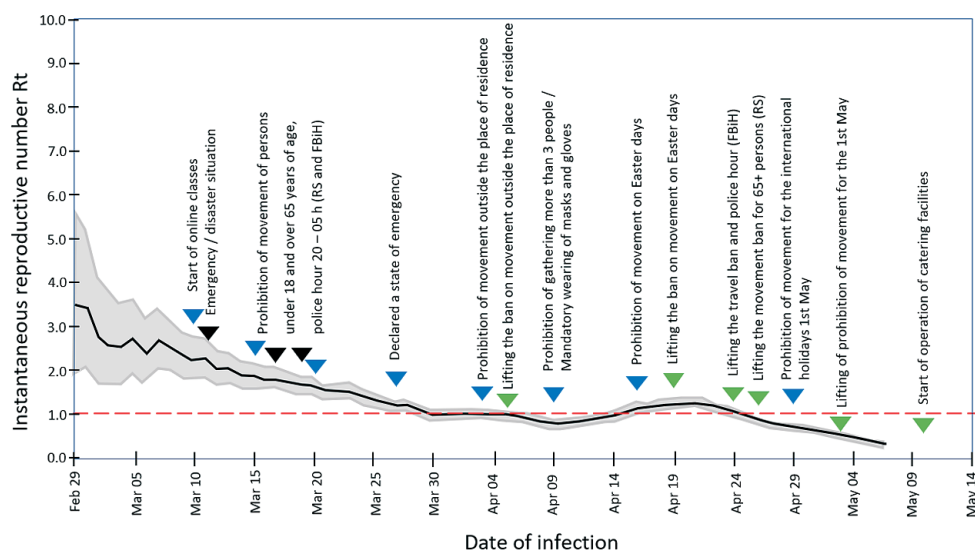


Figure 4.3. Instantaneous reproduction number R_t for Bosnia and Herzegovina (until 14 May 2020) with an overview of the introduction of restrictive measures in the Federation of BiH (black triangles) and Republika Srpska (blue triangles), and with relaxed measures (green triangles)

day intervals, a technique with a series of maps was used. Time-lining animation³⁶ was used to simultaneously show the growth of the cumulative number of infected people by municipalities in Bosnia and Herzegovina (Figure 4.4).

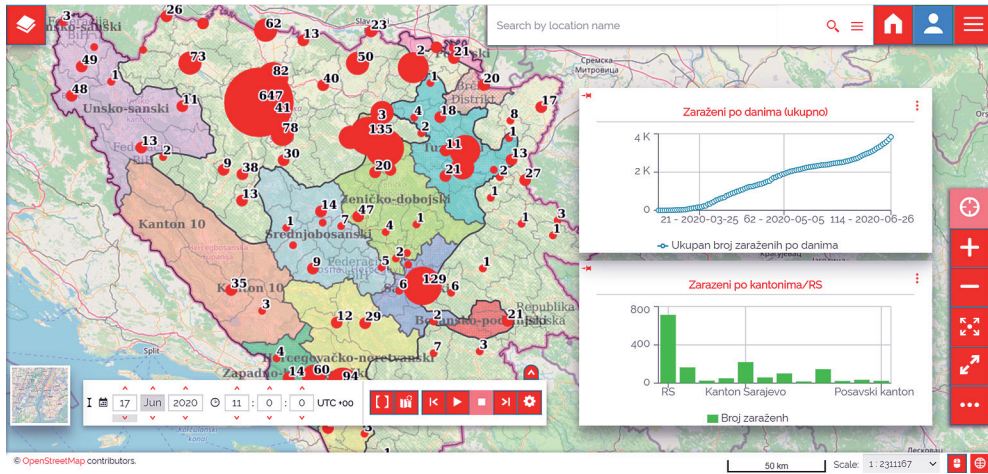


Figure 4.4. ELIS geoportal: Time-lining animation of the cumulative number of confirmed COVID-19 cases by municipalities in Bosnia and Herzegovina (June 17, 2020)

5. RESULTS OF THE ANALYSIS OF COVID-19 SPREAD AND EVALUATION OF THE EPIDEMIOLOGICAL SITUATION

All obtained results related to the chronology of events (I), the distribution of infected (II), disease statistics (III), the dynamics of infection spread (IV) and the reproduction number R_t (V) were organized in five sections (marked with Roman numerals) for each spatial unit (country, entities, district and cantons) in Bosnia and Herzegovina and the sixth section (VI), are briefly discussed.

The results of the analysis are presented in the following order:

- Bosnia and Herzegovina
- Federation of Bosnia and Herzegovina
- Republika Srpska
- Brčko District of Bosnia and Herzegovina
- Una-Sana Canton
- Posavina Canton
- Tuzla Canton
- Zenica-Doboj Canton
- Bosnian-Podrinje Canton
- Central Bosnia Canton
- Herzegovina-Neretva Canton
- West Herzegovina Canton
- Sarajevo Canton
- Canton 10

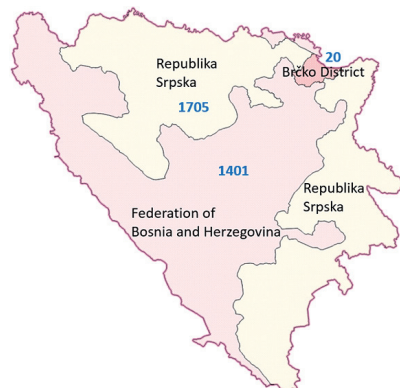
The obtained results presented in this publication are subject to daily changes of the epidemic situation in the region of analysis, as well as the quality of actual input data.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR BOSNIA AND HERZEGOVINA (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 5, 2020	The first confirmed case of infection in the place (city / entity): Banjaluka, Republika Srpska.
June 17, 2020	Reporting date. Total number of cases on the reporting date: 3126.

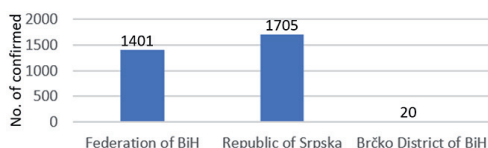
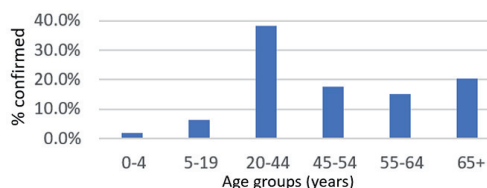
II. Spatial distribution of the infected in BiH



III. Disease statistics

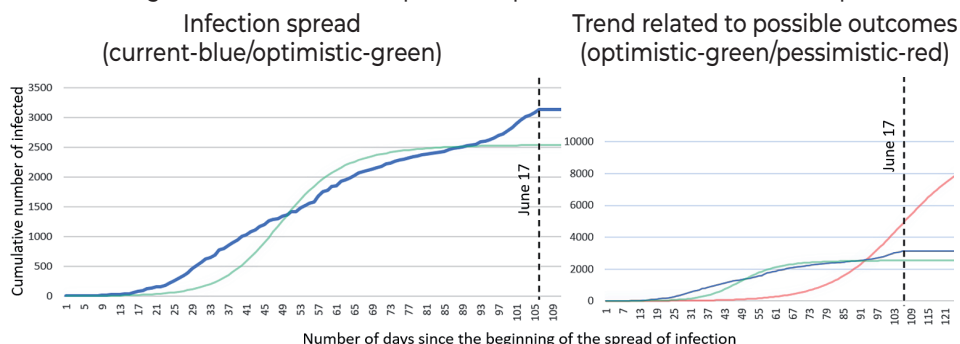
Age and gender structure of diseased and their distribution

Infected	Number	% of total infected	% of the total population in the group
Total	3126	100%	0,09%
0-4 year	59	1,9%	0,03%
5-19 year	198	6,3%	0,03%
20-44 year	1202	38,5%	0,10%
45-54 year	552	17,7%	0,10%
55-64 year	475	15,2%	0,10%
65+ year	638	20,4%	0,13%
Male	1487	47,6%	0,09%
Female	1639	52,4%	0,09%
Deaths	168	5,4%	0,005%



IV. Dynamics of infection spread in Bosnia and Herzegovina

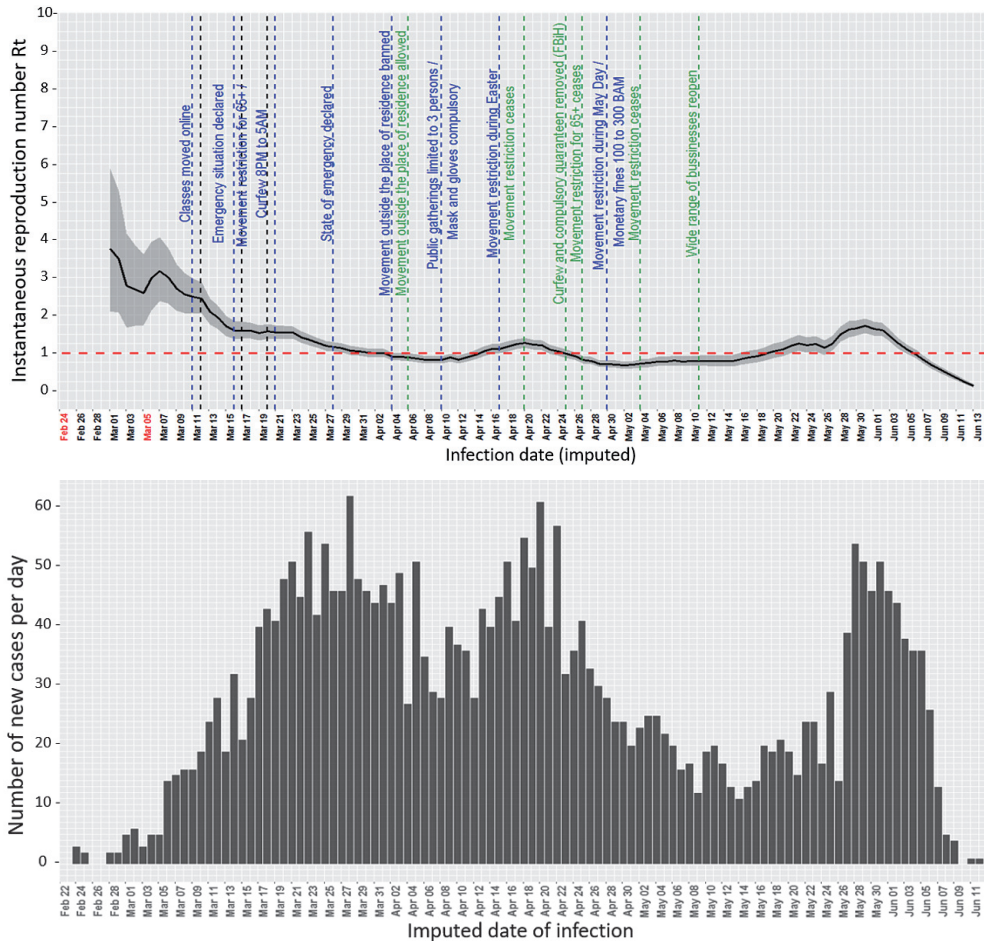
Current growth of infected and optimistic / pessimistic model of infection spread



No. of days of doubling of the infected ($1/\beta$): 3.63
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 2.51
Herd immunity threshold ($1-1/\beta/\gamma$): 0.60

V. Instantaneous reproductive number R_t and diagram of the newly infected per day



VI. A brief overview of the epidemic situation in Bosnia and Herzegovina

The diagrams related to the dynamics of the spread of the infection (section IV) show a continuous increase in the number of confirmed cases. In the period from May 10 to June 10, 2020 the spread of the infection had a declining trend. The R_t diagram (section V) shows that in the period from May 5 to May 30, 2020 the instantaneous reproductive number was below 1 (the date was shifted back by the number of incubation days from the date of symptom onset). This was the result of the successful implementation of control measures, the activities of epidemiological response teams and the discipline of the population. However, after this period, the R_t number was above 1 (ranging to 1.8), and in the last 7 days of the reporting period (June 10-17) it dropped below 1. The growing trend (section IV) from June 5 indicates the possibility of a further increase in the number of infected cases.

The largest number of confirmed cases refers to the age group of 20-44 years (38.5%), and the most severely affected population is the age group of over 65 years (0.13%). The total morbidity of the population in the reporting period reaches 0.09% (3126 confirmed cases), and the number of deaths participates with 5.4% of the total number of confirmed cases, i.e. 0.005% of the total population. The infection rate for males is 47.6% (1487 cases) and females 52.4% (1639 cases). A large number of confirmed cases was registered in the cities of Banja Luka (647), Sarajevo (129), Tuzla (98) and Mostar (94), and in the municipalities of Maglaj (147), Tešanj (135), Čitluk (96) and Laktaši (82). .

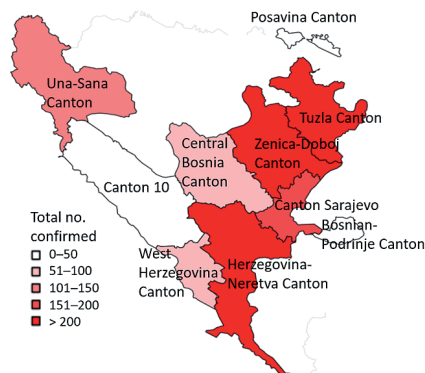
In the coming period, it is necessary to continue to conduct increased epidemiological surveillance, insisting on the mandatory use of masks, the avoidance of physical contact, physical distance, hygiene measures, restrictions on indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR FEDERATION OF BOSNIA AND HERZEGOVINA (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 9, 2020	The first confirmed case of infection in the place (city / municipality): Zenica (Zenica-Doboj Canton)
June 17, 2020	Total number of cases on the reporting date: 1401

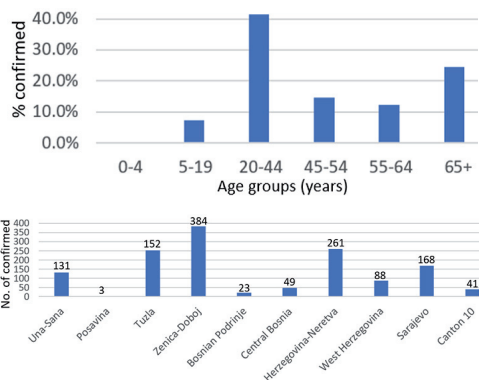
II. Spatial distribution of the infected by cantons



III. Disease statistics

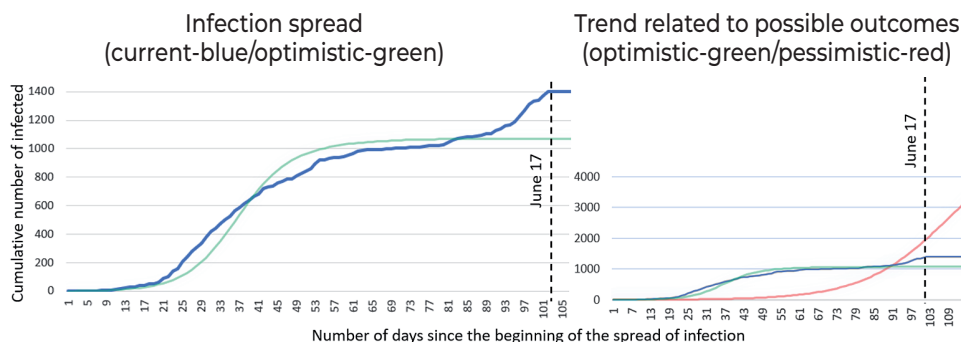
Age and gender structure of the diseased and their distribution by cantons

Infected	Number	% of total infected	% of the total population in the group
Total	3401	100%	0,06%
0-4 year	29	2,1%	0,03%
5-19 year	147	10,5%	0,03%
20-44 year	550	39,3%	0,07%
45-54 year	249	17,8%	0,07%
55-64 year	221	15,8%	0,08%
65+ year	205	14,6%	0,07%
Male	634	45,3%	0,06%
Female	767	54,7%	0,07%
Deaths	45	3,2%	0,002%



IV. Dynamics of infection spread in Federation of Bosnia and Herzegovina

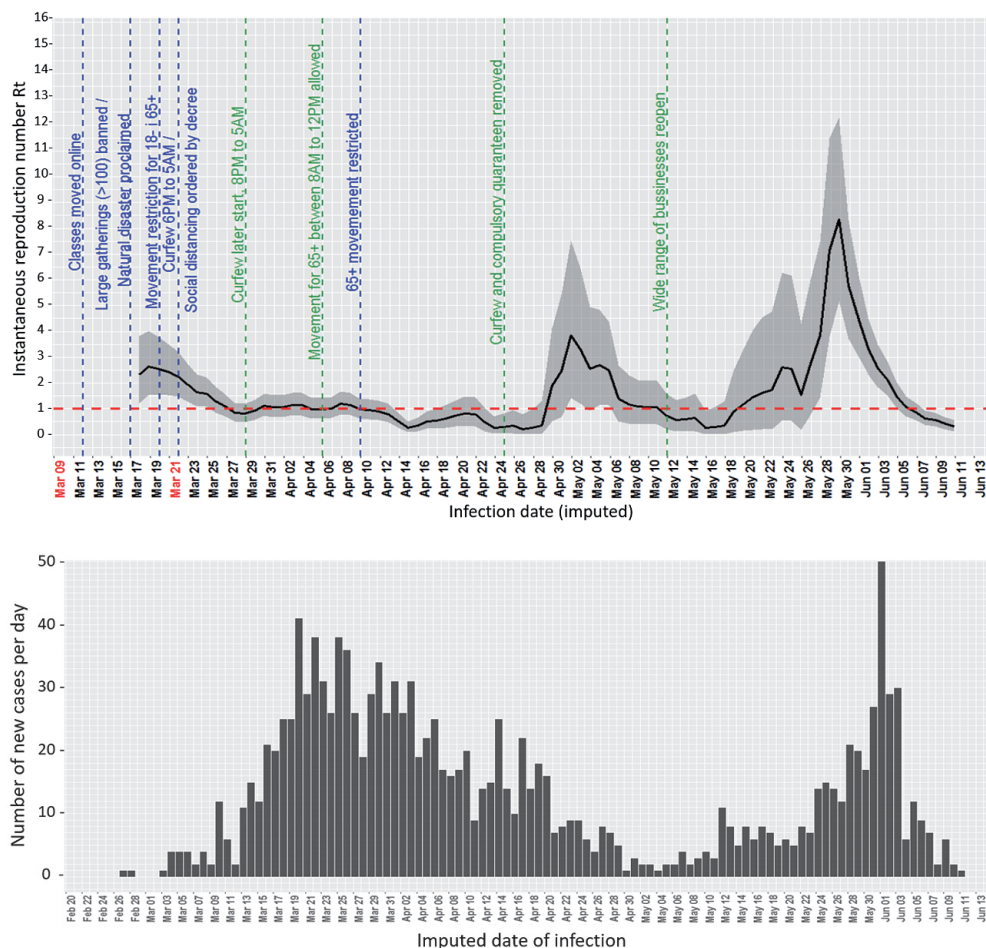
Current growth of infected and optimistic / pessimistic model of the infection spread



No. of days of doubling of the infected ($1/\beta$): 3.24
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 2.81
Herd immunity threshold ($1-1/\beta/\gamma$): 0.64

V. Instantaneous reproductive number R_t and diagram of newly infected per day



VI. A brief overview of the epidemic situation in Federation of Bosnia and Herzegovina

The diagrams describing the dynamics of the spread of the infection (section IV) show a continuous increase in the number of confirmed cases. During the period from May 5 to June 10, 2020 the spread of the infection was in a declining trend. The R_t diagram (section V) shows that in the period from April 10 to May 20 the instantaneous reproductive number was below 1 (the date was shifted back by the number of incubation days from the date of symptom onset). This was the result of the implementation of control measures, the activities of epidemiological response teams and the discipline of the population. However, after this period, the R_t number was mostly above 1, and in the last 5 days of the reporting period (June 12 – June 17) it dropped

below 1. The growing trend (section IV) from June 10 indicates the possibility of a further increase in the number of infected cases.

The largest number of infected cases refers to the age group of 20-44 years (39.3%), and the most severely affected population is the age group 55-64 years (0.08%). The total morbidity of the population in the reporting period reaches 0.06% (1401 confirmed cases), and the number of deaths participates with 3.2% of the total number of confirmed cases, or 0.002% of the total population. The largest number of the confirmed cases was registered in Zenica-Doboj (384), Tuzla (252) and Herzegovina-Neretva Canton (261).

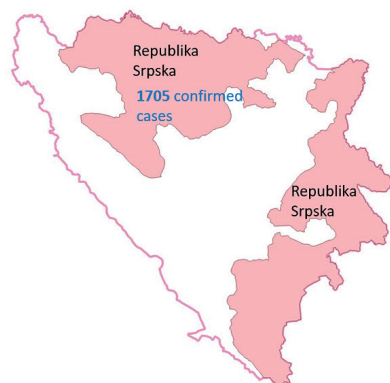
In the coming period, it is necessary to conduct intensified epidemiological surveillance, insisting on the obligatory use of masks, the avoidance of physical contact, physical distance, hygienic measures, restrictions related to indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR REPUBLIC OF SRPSKA (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 5, 2020	The first confirmed case of infection in the place (city / municipality): Banjaluka.
June 17, 2020	Total number of cases on the reporting date: 1705.

II. Spatial distribution of the infected cases

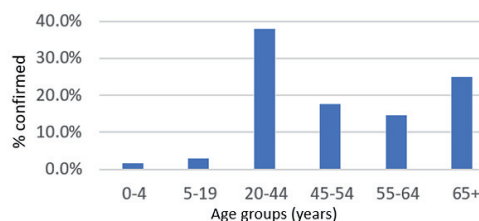


III. Disease statistics

Age and gender structure of diseased

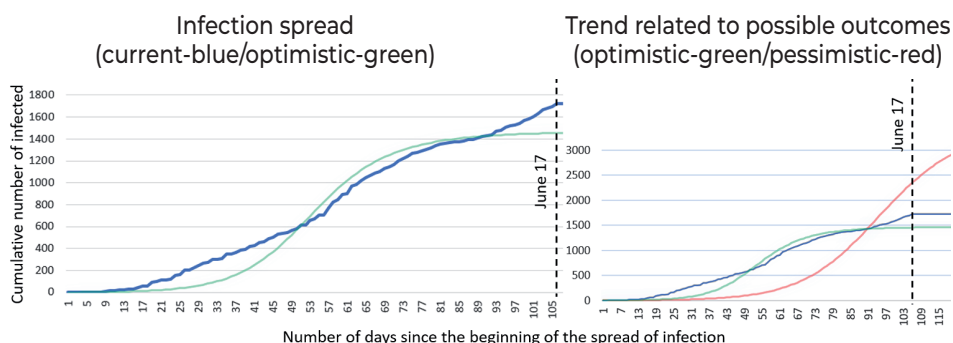
Infected	Number	% of total infected	% of the total population in the group
Total	1705	100%	0,14%
0-4 year	30	1,8%	0,05%
5-19 year	49	2,9%	0,02%
20-44 year	648	38,0%	0,16%
45-54 year	301	17,7%	0,16%
55-64 year	250	14,7%	0,13%
65+ year	427	25,0%	0,21%
Male	845	49,6%	0,14%
Female	860	50,4%	0,14%
Deaths	119	7,0%	0,010%

Age structure and prevalence of confirmed cases



IV. Dynamics of infection spread in Republika Srpska

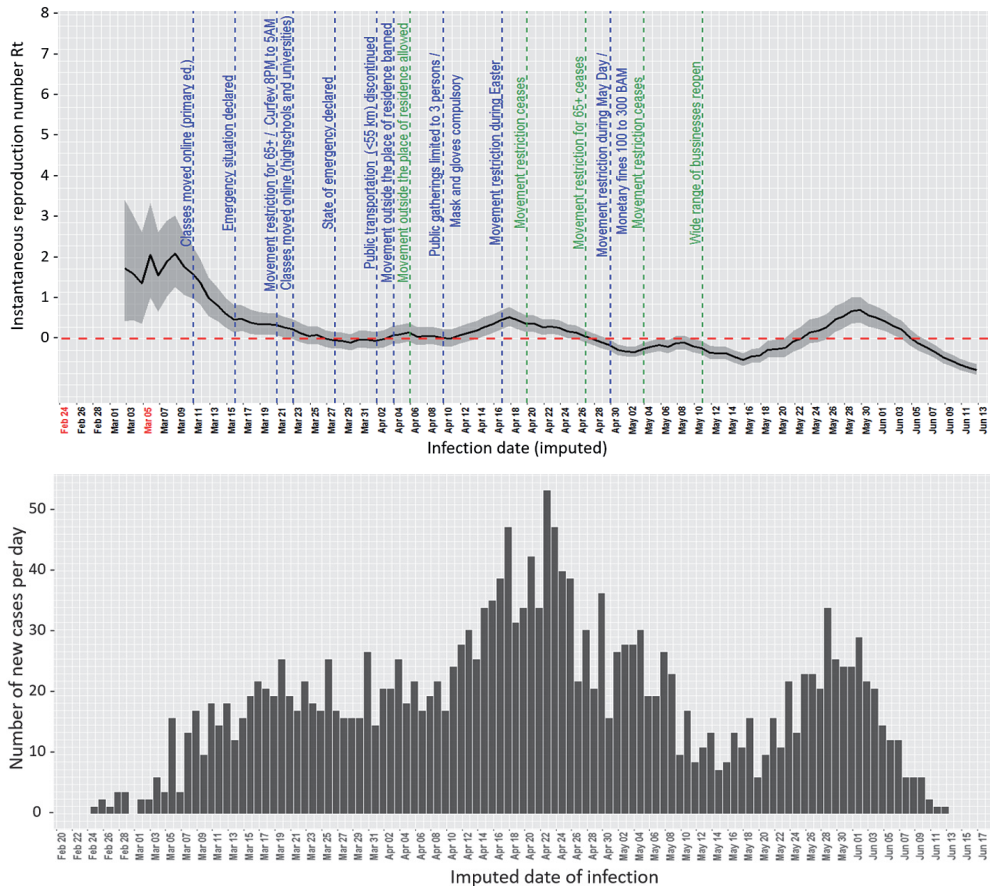
Current growth of infected and optimistic / pessimistic model of the infection spread



No. of days of doubling of the infected ($1/\beta$): 4.06
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 2.24
Herd immunity threshold ($1-1/\beta/\gamma$): 0.55

V. Instantaneous reproductive number R_t and diagram of newly infected per day



VI. A brief overview of the epidemic situation in Republika Srpska

The diagrams related to the dynamics of the spread of the infection (section IV) show a continuous increase in the number of confirmed cases. In the period from May 20 to June 5, 2020 the spread of infection was in a declining trend. The R_t diagram (section V) shows that in the period from May 10 to May 30 the current reproductive number was below 1 (the date was shifted back by the number of incubation days from the date of symptom onset). This was the result of the successful implementation of control measures, the activities of epidemiological response teams and the discipline of the population. However, after this period, the R_t number was above 1 (up to 1.6), and in the last 7 days of the reporting period (June 10-17) it dropped below 1. The growing trend (section IV) from June 5 indicates the possibility of a further increase in the number of infected cases.

The largest number of the infected cases refers to the age group of 20-44 years (38.0%), and the most severely affected population is the age group of over 65 years

(0.21%). The total morbidity of the population in the reporting period reaches 0.14% (1705 confirmed cases), and the number of deaths participates with 7.0% of the total number of confirmed cases, or 0.010% of the total population. The largest number of the infected cases was registered in Banja Luka (647).

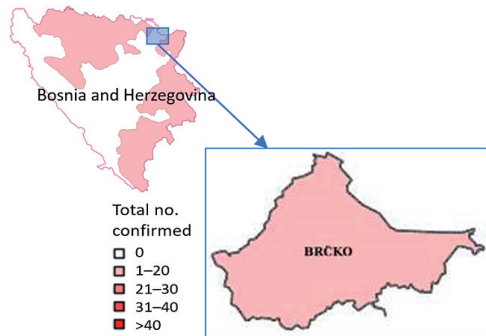
In the coming period, it is necessary to continue to conduct increased epidemiological surveillance, insisting on the mandatory use of masks, the avoidance of physical contact, physical distance, hygiene measures, restrictions on indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR BRČKO DISTRICT OF BOSNIA AND HERZEGOVINA (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 27, 2020	The first confirmed case of infection in the place (city / municipality): Brčko.
April 25, 2020	Beginning of a period of at least two weeks with no new cases. Total number of cases to this date: 19.
May 14, 2020	The first case after the period of at least two weeks with no new cases.
June 17, 2020	Total number of cases on the reporting date: 20.

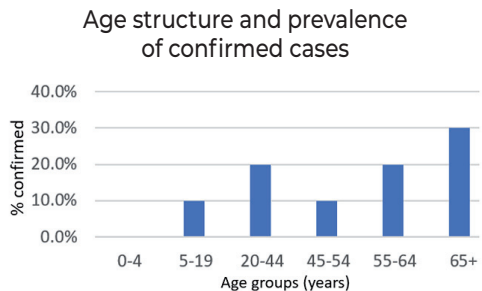
II. Spatial distribution of the infected cases



III. Disease statistics

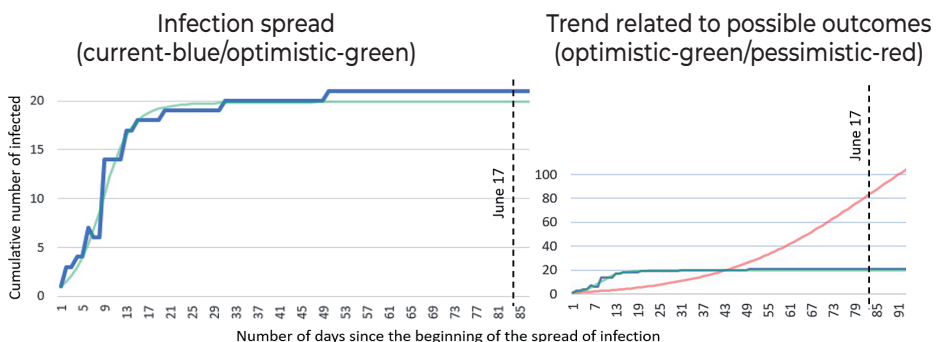
Age and gender structure of the diseased

Infected	Number	% of total infected	% of the total population in the group
Total	20	100%	0,02%
0-4 year	0	0,0%	0,00%
5-19 year	2	10,0%	0,01%
20-44 year	4	20,0%	0,01%
45-54 year	2	10,0%	0,02%
55-64 year	4	20,0%	0,04%
65+ year	6	30,0%	0,05%
Male	8	40,0%	0,02%
Female	12	60,0%	0,03%
Deaths	4	20,0%	0,005%



IV. Dynamics of infection spread in Brčko District

Current growth of infected and optimistic / pessimistic model of the infection spread



No. of days of doubling of the infected ($1/\beta$): 2.00
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 4.54
Herd immunity threshold ($1-1/\beta/\gamma$): 0.78

V. Instantaneous reproductive number R_t

Instantaneous reproduction number R_t is not done due to the small number of confirmed cases.

VI. A brief overview of the epidemic situation in Brčko District

The diagrams related to the dynamics of the spread of infection (section IV) show that the trend of the spread of infection from April 25, 2020 stopped, which can be attributed to the successful implementation of control measures, the epidemiological response team and the discipline of the population.

A total of 20 cases of the infection were confirmed, of which the largest number of confirmed cases refers to the age group over 65 years (30.0%), which is also the most severely affected population (0.05%). The total morbidity of the population in the reporting period reaches 0.02%, with 4 deaths registered (20% of the total confirmed cases of the infection).

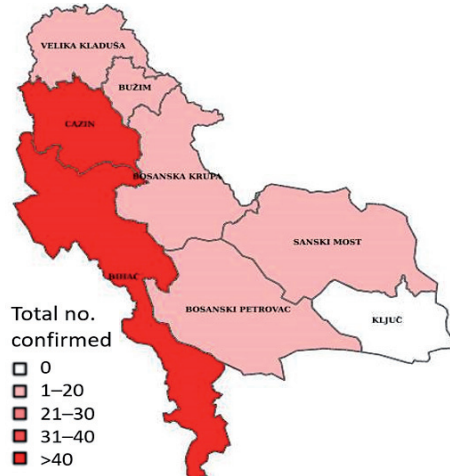
Although the epidemiological situation has been stable for a long time (52 days with only one new case), due to the abolition of restrictive epidemiological measures and relaxation of the population, an increase in infected cases can be expected in the coming period. In this sense, it is necessary to insist on the obligatory use of masks, the avoidance of physical contact, physical distance, hygienic measures, restrictions related to indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR UNA-SANA CANTON (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 17, 2020	The first confirmed case of infection in the place (city / municipality): Bihać
May 14, 2020	Beginning of a period of at least two weeks with no new cases. Total number of cases to this date: 107.
June 2, 2020	The first case after the period of at least two weeks with no new cases.
June 17, 2020	Reporting date. Total number of cases on the reporting date: 131.

II. Spatial distribution of the infected cases

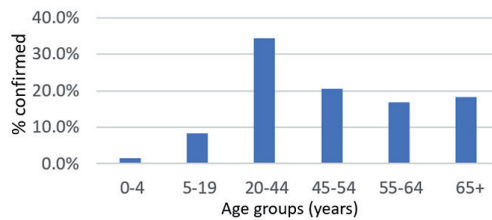


III. Disease statistics

Age and gender structure of the diseased and their distribution by cities / municipalities

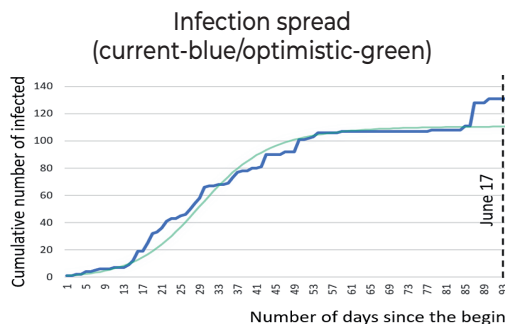
Infected	Number	% of total infected	% of the total population in the group
Total	131	100%	0,05%
0-4 year	2	1,5%	0,01%
5-19 year	11	8,4%	0,02%
20-44 year	45	34,4%	0,04%
45-54 year	27	20,6%	0,07%
55-64 year	22	16,8%	0,07%
65+ year	24	18,3%	0,08%
Male	61	46,6%	0,05%
Female	70	53,4%	0,05%
Deaths	10	7,6%	0,004%

Age structure and prevalence of confirmed cases

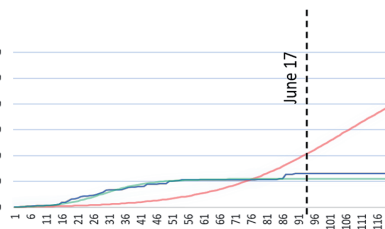


IV. Dynamics of infection spread in Una-Sana Canton

Current growth of infected and optimistic / pessimistic model of the infection spread



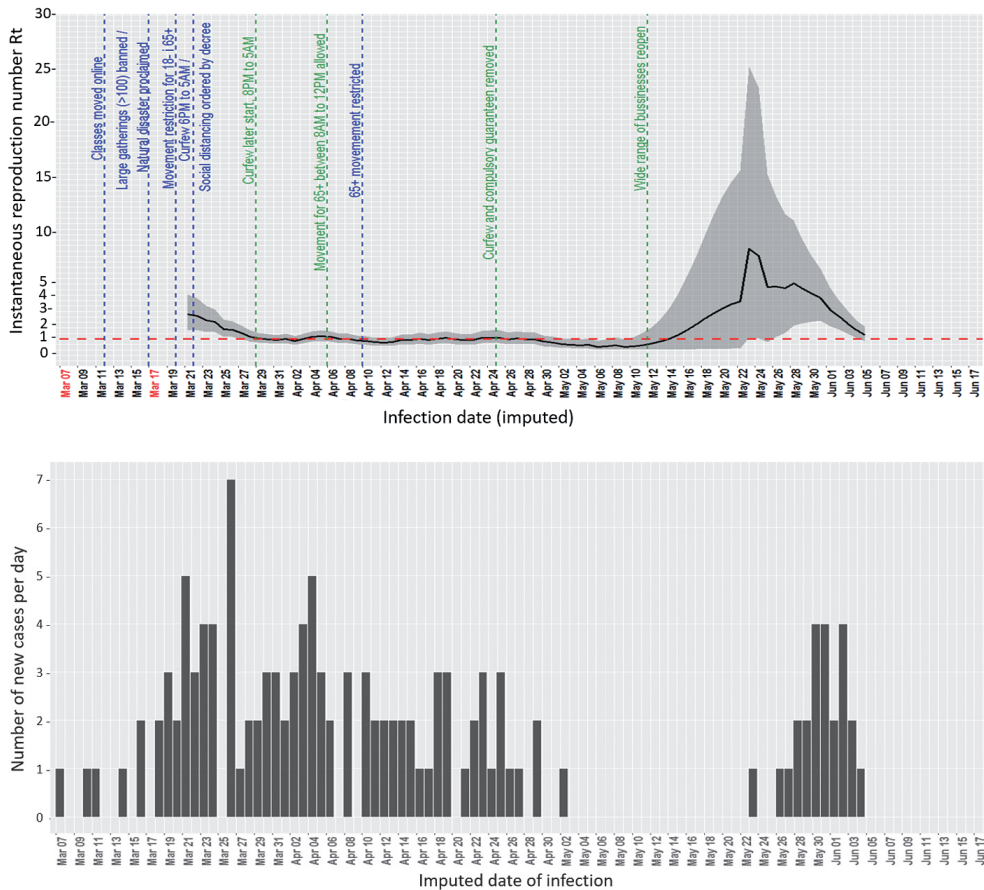
Trend related to possible outcomes (optimistic-green/pessimistic-red)



No. of days of doubling of the infected ($1/\beta$): 3.76
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 2.42
Herd immunity threshold ($1-1/\beta/\gamma$): 0.59

V. Instantaneous reproductive number R_t and diagram of newly infected per day



VI. A brief overview of the epidemic situation in Una-Sana Canton

According to the diagrams (section IV and V), the epidemic situation stabilized and the pessimistic scenario was avoided (as observed in countries such as Italy and Spain), but the number of infected cases began to grow again. The trend of spreading infection from April 15 was on the decline, and on May 14 it stopped at a total of 107 confirmed cases of the infection. The initial halt to the spread of infection is the result of the successful operation of control measures, the activities of epidemiological response teams and the discipline of the population. From June 2 to June 17, the trend of spreading infection starts to grow again when it reaches the total number of 131 confirmed cases of infection.

The largest number of the infected cases refers to the age group of 20-44 years (34.4%), and the most severely affected population is the age group of over 65 years (0.08%). The total morbidity of the population in the reporting period reaches 0.05%,

and the number of deaths participates with 7.6% of the total number of infected, or 0.004% of the total population (with a higher rate from age groups over 65 years).

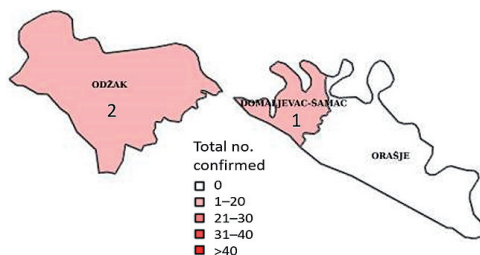
In the coming period, the situation could continue to deteriorate due to the abolition of restrictive control measures, rapid relaxation of the population, and non-compliance with measures related to physical distance, wearing masks and mass gatherings. Special attention during epidemic surveillance should be paid to the more densely populated areas in the city of Bihać and the municipality of Cazin, where a significantly higher number of the infected cases is recorded compared to other municipalities. In this context, it is necessary to conduct intensified epidemiological surveillance, insisting on the mandatory use of masks, the avoidance of physical contact, physical distance, hygiene measures, restrictions on indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR POSAVINA CANTON (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 16, 2020	The first confirmed case of infection in the place (city / municipality): Domaljevac.
March 27, 2020	Beginning of a period of at least two weeks with no new cases. Total number of cases to this date: 3.
June 17, 2020	Total number of cases on the reporting date: 3.

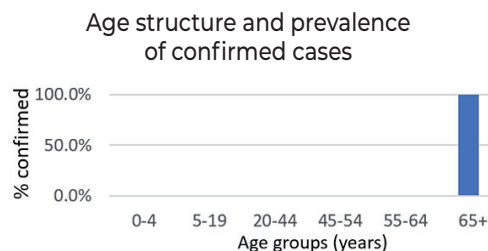
II. Spatial distribution of the infected cases by municipalities



III. Disease statistics

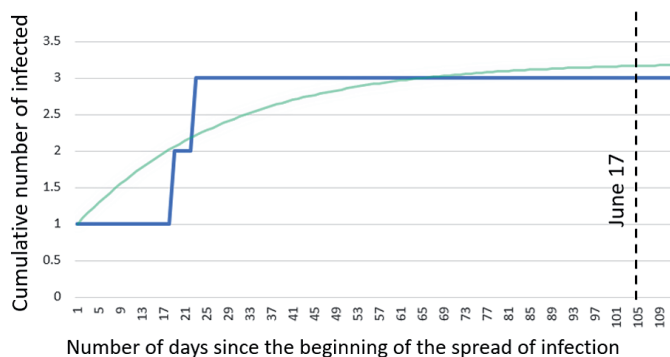
Age and gender structure of the diseased and their distribution by cities / municipalities

Infected	Number	% of total infected	% of the total population in the group
Total	3	100%	0,01%
0-4 year	0	0,0%	0,00%
5-19 year	0	0,0%	0,00%
20-44 year	0	0,0%	0,00%
45-54 year	0	0,0%	0,00%
55-64 year	0	0,0%	0,00%
65+ year	3	100,0%	0,05%
Male	1	33,3%	0,005%
Female	2	66,7%	0,01%
Deaths	0	0,0%	0,00%



IV. Dynamics of infection spread

Current growth of infected and optimistic / pessimistic model of infection spread (current-blue/optimistic-green)



V. Instantaneous reproductive number R_t

Instantaneous reproduction number R_t is not done due to small number of confirmed cases.

VI. A brief overview of the epidemic situation in Posavina Canton

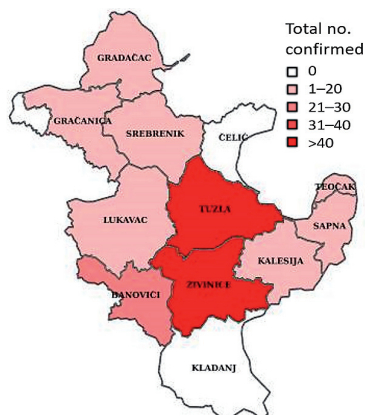
During the reporting period, 3 confirmed infected cases (1 male and two female persons over 65 years of age) were recorded, of which one was hospitalized. The epidemiological situation at the time of reporting (June 17, 2020) was stable, but increased epidemiological surveillance is necessary due to the frequent state border crossing in Orašje.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR TUZLA CANTON (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 27, 2020	The first confirmed case of infection in the place (city / municipality): Tuzla and Lukavac.
April 12, 2020	Beginning of a period of at least two weeks with no new cases. Total number of cases to this date: 84.
April 28, 2020	The first case after the period of at least two weeks with no new cases.
June 17, 2020	Total number of cases on the reporting date: 252.

II. Spatial distribution of the infected cases by municipalities

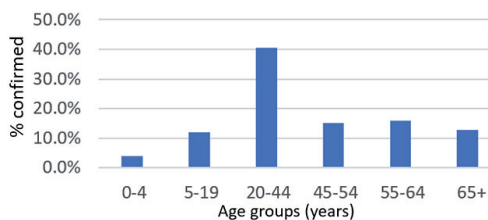


III. Disease statistics

Age and gender structure of the diseased and their distribution by cities / municipalities

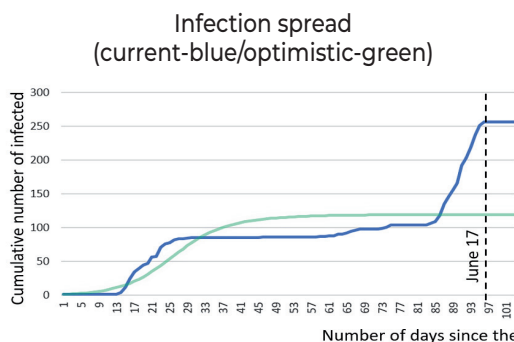
Infected	Number	% of total infected	% of the total population in the group
Total	252	100%	0,06%
0-4 year	10	4,0%	0,04%
5-19 year	30	11,9%	0,03%
20-44 year	102	40,5%	0,06%
45-54 year	38	15,1%	0,05%
55-64 year	40	15,9%	0,07%
65+ year	32	12,7%	0,06%
Male	114	42,2%	0,05%
Female	138	54,8%	0,06%
Deaths	5	2,0%	0,001%

Age structure and prevalence of confirmed cases

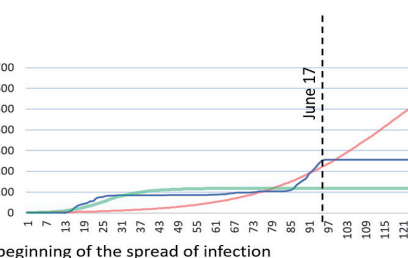


IV. Dynamics of infection spread in Tuzla Canton

Current growth of infected and optimistic / pessimistic model of the infection spread



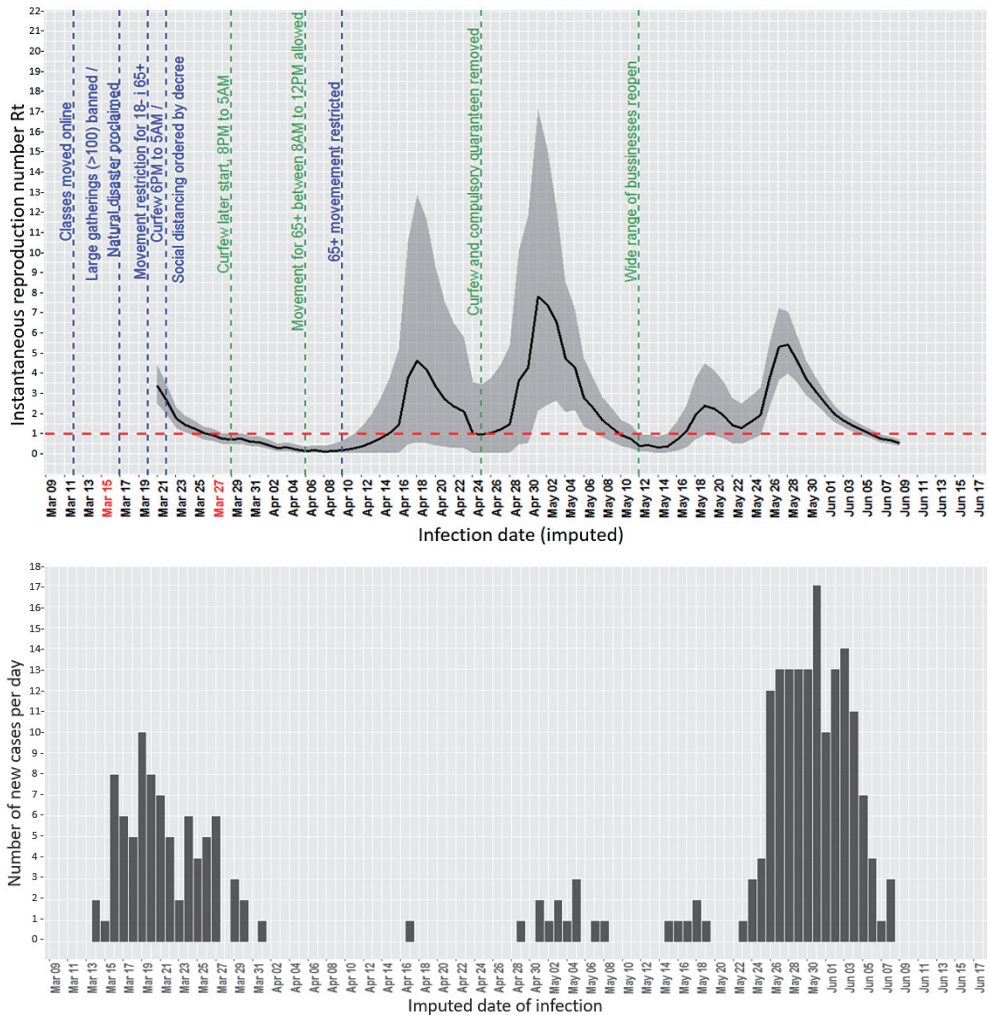
Trend related to possible outcomes
(optimistic-green/pessimistic-red)



No. of days of doubling of the infected ($1/\beta$): 3.38
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 2.69
Herd immunity threshold ($1-1/\beta/\gamma$): 0.63

V. Instantaneous reproductive number R_t and diagram of newly infected per day



VI. A brief overview of the epidemic situation in Tuzla Canton

Diagrams of the dynamics of the infection spread (section IV) show that after April 12, 2020 the trend of spreading infection in Tuzla Canton had decreased and that it had stopped for a long time (until April 28) (with a total of 84 confirmed cases). The R_t diagram shows that during this period the instantaneous reproductive number reached the value 0 (the date was shifted backwards by the number of incubation days from the date of symptom onset). The initial halt to the spread of infection is the result of the successful implementation of control measures, the activities of epidemiological teams and the discipline of the population. However, after this period, from April 28, 2020, the situation worsened and the R_t number fluctuated from 0 to

7, and at the time of reporting it fell slightly below 1 (when 252 confirmed cases of infection were recorded). Furthermore, the growth trend (section IV) from June 6 to June 17 (blue line) began to follow the pessimistic expectation (red line), which indicates the possibility of a further increase in the number of infected cases.

The largest number of confirmed cases refers to the age group of 20-44 years (40.5%), and the most severely affected population was the age group of 55-64 years (0.07%). The total morbidity of the population in the reporting period reached 0.06%, and the number of deaths participated with 2.0% of the total confirmed cases, or 0.001% of the total population (all who died were from the age groups 55-74 years). The largest number of the infected was in Tuzla (98) and Živinice (78).

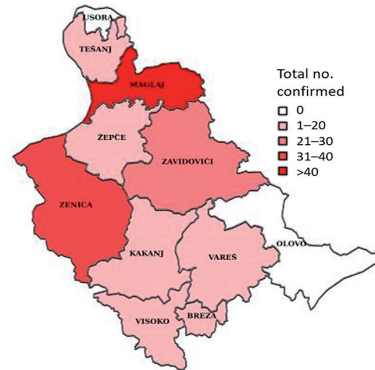
In the following period, a further deterioration of the situation can be expected due to the abolition of restrictive control measures, sudden relaxation of the population, and non-compliance with measures related to physical distance, wearing masks and mass gatherings. In this context, it is necessary to conduct intensified epidemiological surveillance, insisting on the mandatory use of masks, the avoidance of physical contact, physical distance, hygiene measures, restrictions on indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR ZENICA-DOBOJ CANTON (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 9, 2020	The first confirmed case of infection in the place (city / municipality): Zenica.
June 17, 2020	Total number of cases on the reporting date: 384.

II. Spatial distribution of the infected cases by municipalities

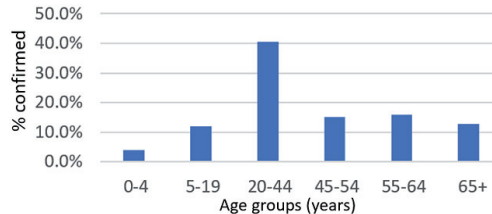


III. Disease statistics

Age and gender structure of the diseased and their distribution by cities / municipalities

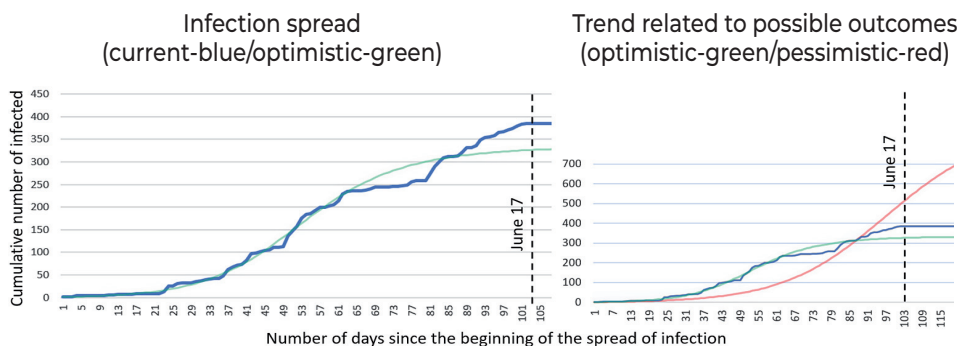
Infected	Number	% of total infected	% of the total population in the group
Total	384	100%	0,11%
0-4 year	4	1,0%	0,02%
5-19 year	49	12,8%	0,06%
20-44 year	176	45,8%	0,14%
45-54 year	81	21,1%	0,14%
55-64 year	40	10,4%	0,08%
65+ year	34	8,9%	0,08%
Male	169	44,0%	0,09%
Female	215	56,0%	0,12%
Deaths	1	0,3%	0,0003%

Age structure and prevalence of confirmed cases



IV. Dynamics of infection spread in Zenica-Doboj Canton

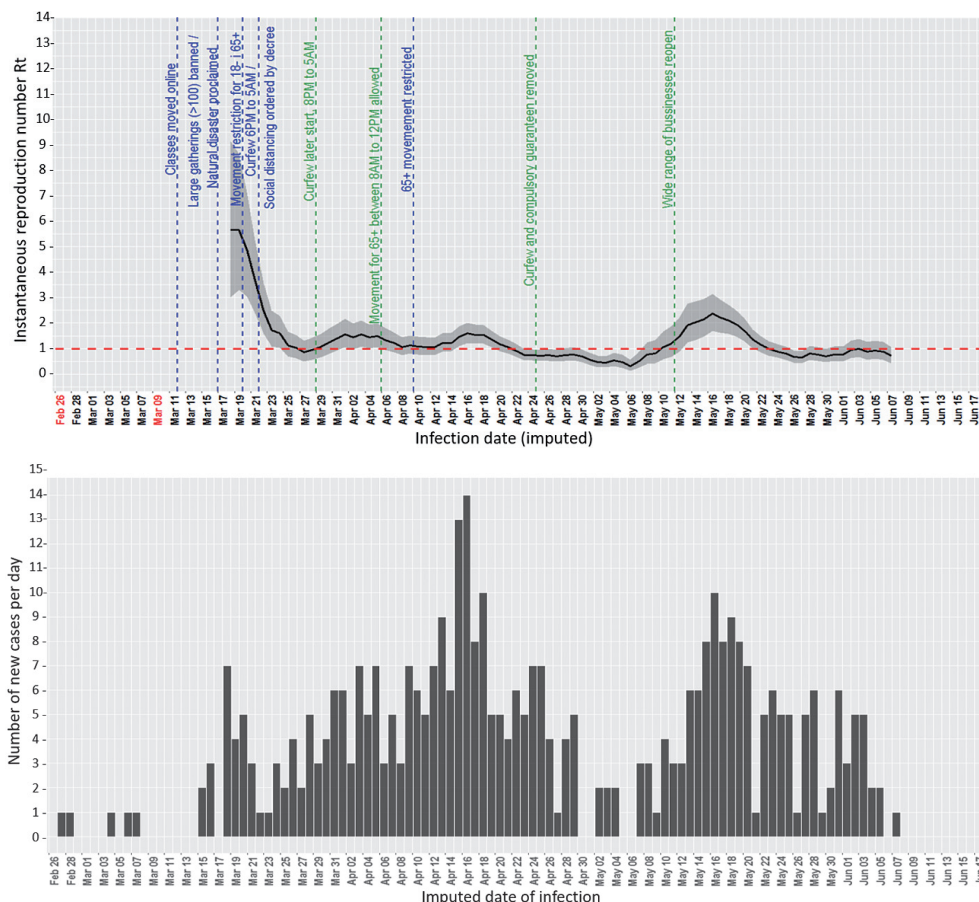
Current growth of infected and optimistic / pessimistic model of the infection spread



No. of days of doubling of the infected ($1/\beta$): 4.69
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 1.94
Herd immunity threshold ($1-1/\beta/\gamma$): 0.48

V. Instantaneous reproductive number R_t and diagram of newly infected per day



VI. A brief overview of the epidemic situation in Zenica-Doboï Canton

Diagrams related to the dynamics of infection spread (section IV) describe a continuous trend of the infection spread. In the period from May 2 to May 16, 2020, there was a decrease in the trend of spreading infection (blue line). R_t diagram (section V) shows that in the same period the current reproduction number was below 1 (date has been moved backwards for the number of incubation days from date of onset of symptoms). It can be attributed to the action of control measures implemented. After this period the situation began to deteriorate and the R_t number increased to 2.5. In the last two weeks, until the time of reporting, the R_t number was below 1, which means that the increase of infection spread was linear.

A total of 384 cases of the infection were confirmed, of which most were registered in Maglaj (147), Tešanj (135) and Zenica (47). The largest number of the infected refers to the age group of 20-44 years (45.8%), which together with the age

group of 45-54 years represents the most severely affected population (0.14%). The total morbidity of the population in the reporting period reached 0.11%, and the number of deaths participated with 0.3% of the total confirmed cases, or 0.0003% of the total population.

In the coming period, an increased growth of the infected cases can be expected due to the abolition of restrictive control measures, sudden relaxation of the population, and non-compliance with measures related to physical distance, wearing masks and mass gatherings. In this context, it is necessary to conduct intensified epidemiological surveillance, insisting on the mandatory use of masks, the avoidance of physical contact, physical distance, hygiene measures, restrictions on indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR BOSNIAN-PODRINJE CANTON (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 19, 2020	The first confirmed case of infection in the place (city / municipality): Goražde
April 17, 2020	Beginning of a period of at least two weeks with no new cases. Total number of cases to this date: 19
May 4, 2020	The first case after the period of at least two weeks with no new cases.
June 17, 2020	Total number of cases on the reporting date: 23.

II. Spatial distribution of the infected cases by municipalities

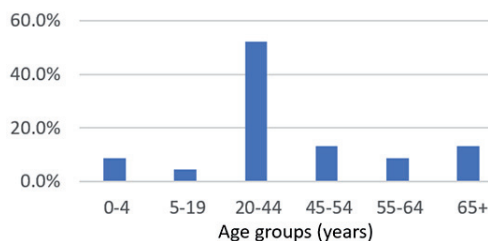


III. Disease statistics

Age and gender structure of the diseased and their distribution by cities / municipalities

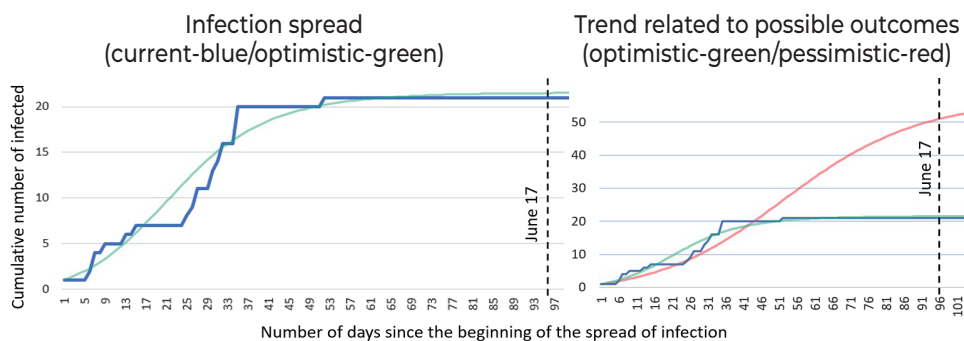
Infected	Number	% of total infected	% of the total population in the group
Total	23	100%	0,10%
0-4 year	2	8,7%	0,18%
5-19 year	1	4,3%	0,02%
20-44 year	12	52,2%	0,16%
45-54 year	3	13,0%	0,08%
55-64 year	2	8,7%	0,05%
65+ year	3	13,0%	0,08%
Male	12	52,2%	0,10%
Female	11	47,8%	0,09%
Deaths	0	0,0%	0,00%

Age structure and prevalence of confirmed cases



IV. Dynamics of infection spread in Bosnian-Podrinje Canton

Current growth of infected and optimistic / pessimistic model of the infection spread



No. of days of doubling of the infected ($1/\beta$): 4.50
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 2.02
Herd immunity threshold ($1-1/\beta/\gamma$): 0.51

V. Instantaneous reproductive number R_t and diagram of newly infected per day

The instantaneous reproduction number R_t is not done due to the small number of confirmed cases.

VI. A brief overview of the epidemic situation in Bosnian-Podrinje Canton

The diagrams related to the dynamics of the spread of infection (section IV) show that the trend of the spread of infection from March 17, 2020 stopped, which can be attributed to the successful operation of control measures, the epidemiological response team and the discipline of the population.

A total of 23 cases of the infection were confirmed, of which the largest number of the infected refers to the age group of 20-44 years (55.2%). The total morbidity of the population in the reporting period reached 0.10%, with no death cases.

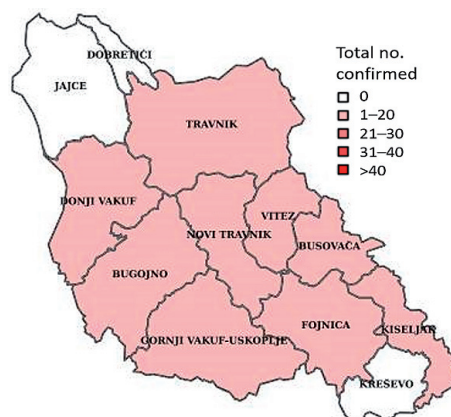
In the coming period, an increased growth of the infected cases can be expected due to the abolition of restrictive control measures. In this context, it is necessary to carry out intensified epidemiological surveillance, insisting on the mandatory use of masks, the avoidance of physical contact, physical distance, hygiene measures, restrictions on indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR CENTRAL BOSNIA CANTON (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 21, 2020	The first confirmed case of infection in the place (city / municipality): Novi Travnik.
May 6, 2020	Beginning of a period of at least two weeks with no new cases. Total number of cases to this date: 43.
June 5, 2020	The first case after the period of at least two weeks with no new cases.
June 17, 2020	Total number of cases on the reporting date: 49.

II. Spatial distribution of the infected cases by municipalities

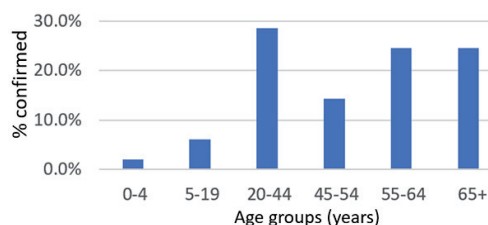


III. Disease statistics

Age and gender structure of the diseased and their distribution by cities / municipalities

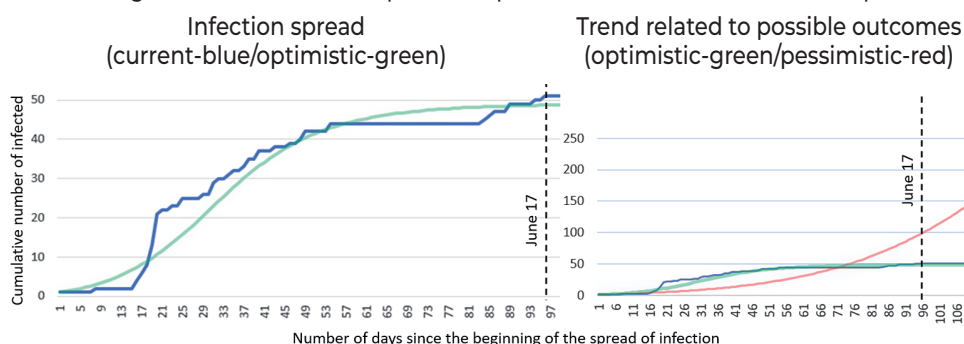
Infected	Number	% of total infected	% of the total population in the group
Total	49	100%	0,02%
0-4 year	1	2,0%	0,01%
5-19 year	3	6,1%	0,01%
20-44 year	14	28,6%	0,02%
45-54 year	7	14,3%	0,02%
55-64 year	12	24,5%	0,04%
65+ year	12	24,5%	0,04%
Male	22	44,9%	0,02%
Female	27	55,1%	0,02%
Deaths	4	8,2%	0,002%

Age structure and prevalence of confirmed cases



IV. Dynamics of infection spread in Central Bosnia Canton

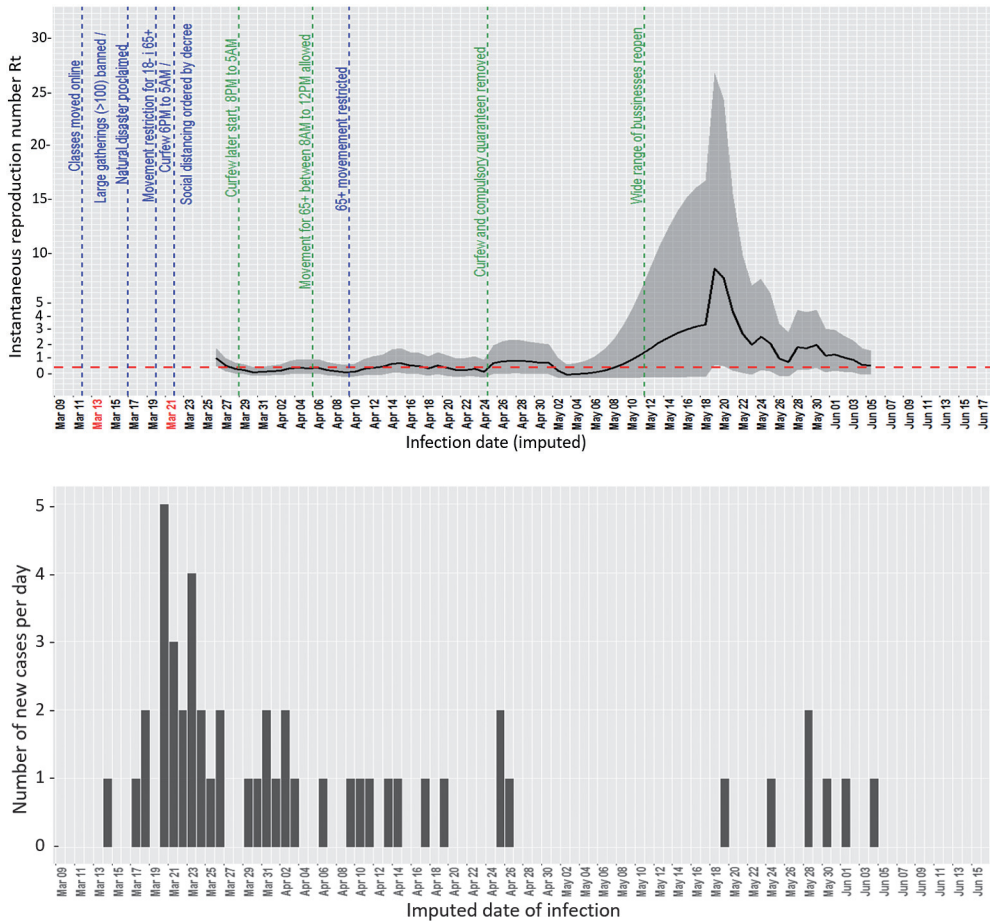
Current growth of infected and optimistic / pessimistic model of the infection spread



No. of days of doubling of the infected ($1/\beta$): 4.61
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 1.97
Herd immunity threshold ($1-1/\beta/\gamma$): 0.49

V. Instantaneous reproductive number R_t and diagram of newly infected per day



VI. A brief overview of the epidemic situation in Central Bosnia Canton

The diagrams describing the dynamics of the spread of infection (section IV) show that in the period from May 6 to June 5, the epidemic situation stabilized. The reduction in the spread of infection was the result of the successful implementation of control measures, the activities of epidemiological teams and the discipline of the population. From June 6 to June 17, the trend of spreading infection started to grow again when it reached the total number of 49 confirmed cases. In that period, the R_t number fluctuated from 0-9.5, and its value on the reporting day was 1.

The largest number of the confirmed cases refers to the age group of 20-44 years (28.6%), and the most severely affected population are age groups 55-64 (0.04%) and over 65 years (0.04%). The total morbidity of the population in the reporting

period reached 0.02%, and the number of deaths participated with 8.2% of the total number of patients, or 0.002% of the total population.

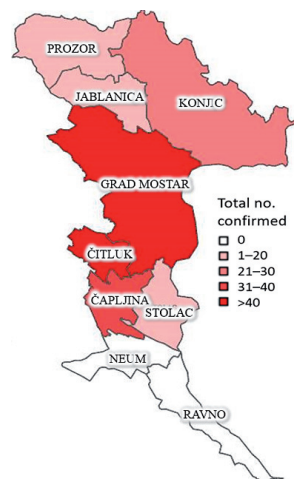
In the coming period, an increase in the number of the infected cases can be expected due to the abolition of restrictive control measures, sudden relaxation of the population, and non-compliance with measures related to physical distance, wearing masks and mass gatherings. In this regard, increased epidemiological surveillance should be carried out, insisting on the mandatory use of masks, the avoidance of physical contact, physical distance, hygiene measures, restrictions on indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR HERZEGOVINA-NERETVA CANTON (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 17, 2020	The first confirmed case of infection in the place (city / municipality): Mostar.
March 10, 2020	Date of symptoms of the first case.
May 1, 2020	Beginning of a period of at least two weeks with no new cases. Total number of cases to this date: 256.
June 6, 2020	The first case after the period of at least two weeks with no new cases.
June 17, 2020	Total number of cases on the reporting date: 261.

II. Spatial distribution of the infected cases by municipalities

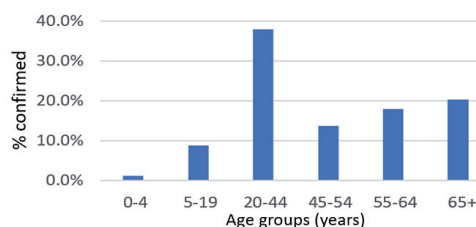


III. Disease statistics

Age and gender structure of the diseased and their distribution by cities / municipalities

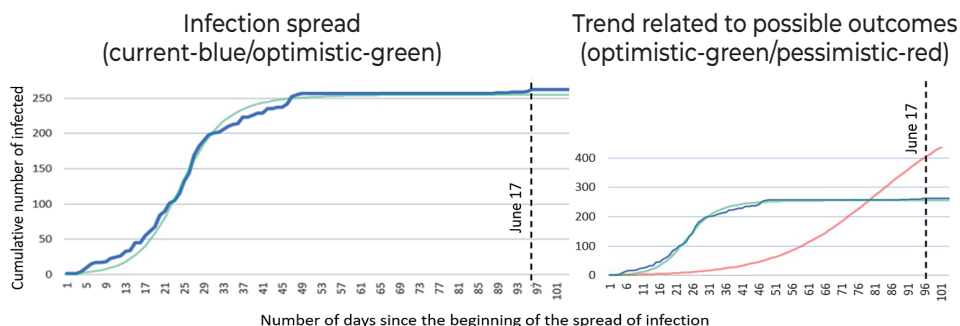
Infected	Number	% of total infected	% of the total population in the group
Total	261	100%	0,12%
0-4 year	3	1,1%	0,03%
5-19 year	23	8,8%	0,05%
20-44 year	99	37,9%	0,13%
45-54 year	36	13,8%	0,11%
55-64 year	47	18,0%	0,16%
65+ year	53	20,3%	0,15%
Male	112	42,9%	0,10%
Female	149	57,1%	0,13%
Deaths	13	5,0%	0,006%

Age structure and prevalence of confirmed cases



IV. Dynamics of infection spread in Herzegovina-Neretva Canton

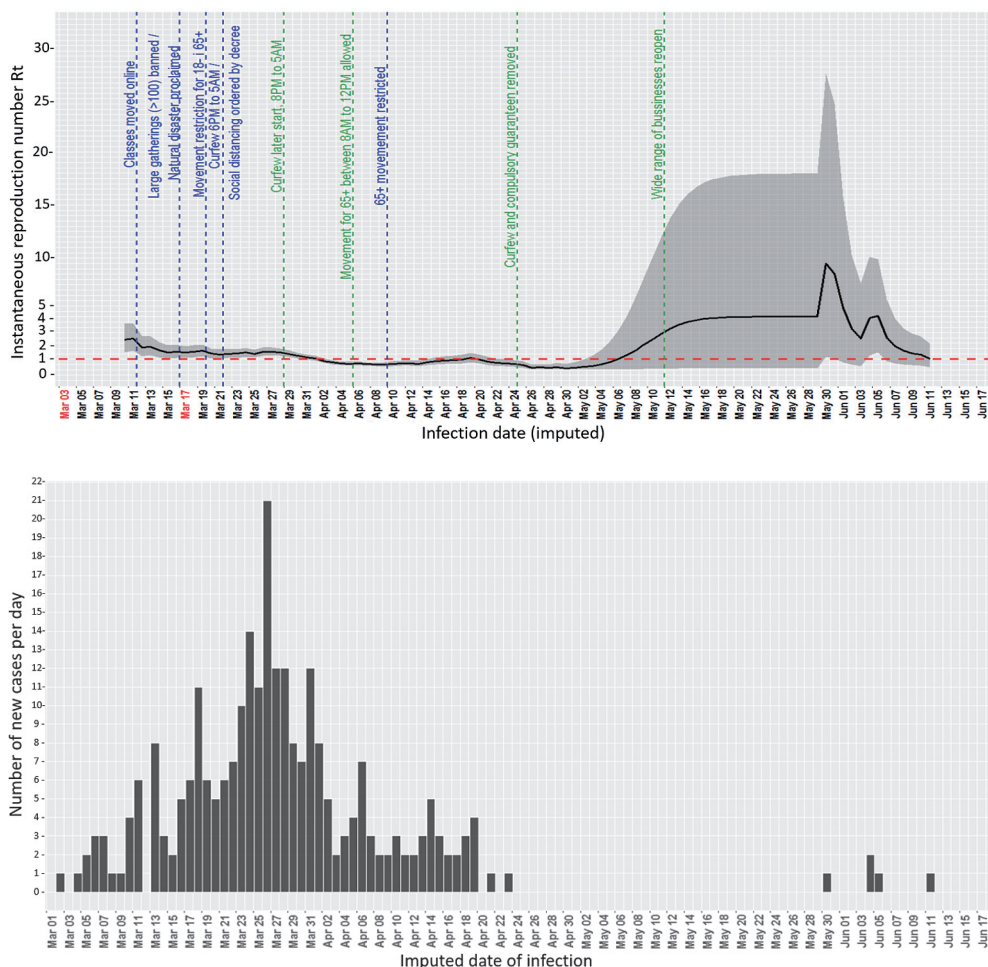
Current growth of infected and optimistic / pessimistic model of the infection spread



No. of days of doubling of the infected ($1/\beta$): 2.82
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 3.22
Herd immunity threshold ($1-1/\beta/\gamma$): 0.69

V. Instantaneous reproductive number R_t and diagram of newly infected per day



VI. A brief overview of the epidemic situation in Herzegovina-Neretva Canton

The diagrams describing the dynamics of the spread of infection (section IV) show that after May 1, 2020 the trend of infection spread decreased and that for a long time the R_t number (section V) was between 0 and 1. Such a stop of the infection spread was the result of successful control measures, implemented activities of epidemiological response teams and discipline of the population. After this period, from June 10, the situation worsened and the R_t number increased to 2 (June 17, 2020), when 5 new cases of the infection were confirmed (total of 261 confirmed cases).

The largest number of the infected cases refers to the age group of 20-44 years (37.9%), and the most severely affected population is the age group 55-64 years

(0.16%). The total morbidity of the population in the reporting period reached 0.12%, and the number of deaths participated with 5.0% of the total number of patients, or 0.006% of the total population. The largest numbers of the infected were in Čitluk (96) and Mostar (94).

In the following period, a further deterioration of the situation can be expected due to the abolition of restrictive control measures, sudden relaxation of the population, and non-compliance with measures related to physical distance, wearing masks and mass gatherings. In this sense, it is necessary to carry out intensified epidemiological surveillance, insisting on the mandatory use of masks, the avoidance of physical contact, physical distance, hygiene measures, restrictions on indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR WEST HERZEGOVINA CANTON (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 23, 2020	The first confirmed case of infection in the place (city / municipality): Široki Brijeg.
May 13, 2020	Beginning of a period of at least two weeks with no new cases. Total number of cases to this date: 88.
June 17, 2020	Total number of cases on the reporting date: 88.

II. Spatial distribution of the infected cases by municipalities

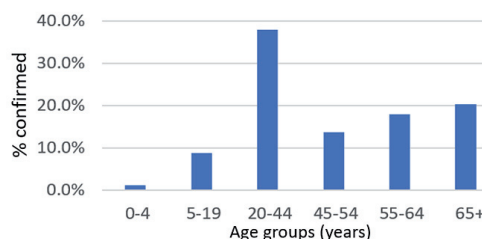


III. Disease statistics

Age and gender structure of the diseased and their distribution by cities / municipalities

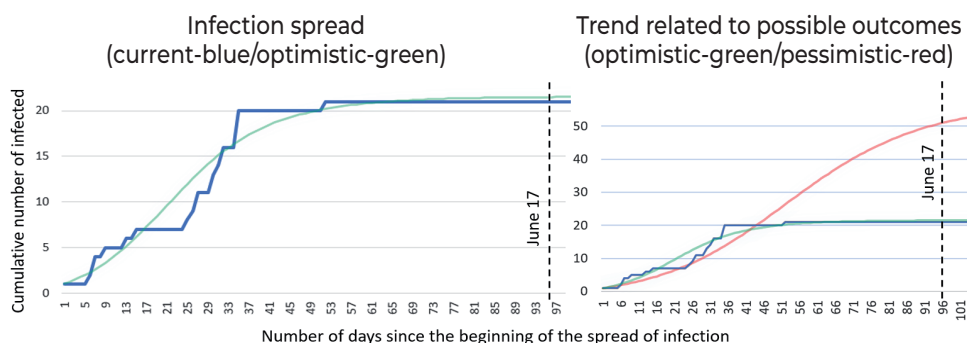
Infected	Number	% of total infected	% of the total population in the group
Total	88	100%	0,09%
0-4 year	2	2,3%	0,04%
5-19 year	18	20,5%	0,07%
20-44 year	23	26,1%	0,08%
45-54 year	13	14,8%	0,07%
55-64 year	15	17,0%	0,09%
65+ year	17	19,3%	0,12%
Male	36	40,9%	0,08%
Female	52	59,1%	0,11%
Deaths	4	4,5%	0,004%

Age structure and prevalence of confirmed cases



IV. Dynamics of infection spread in West Herzegovina Canton

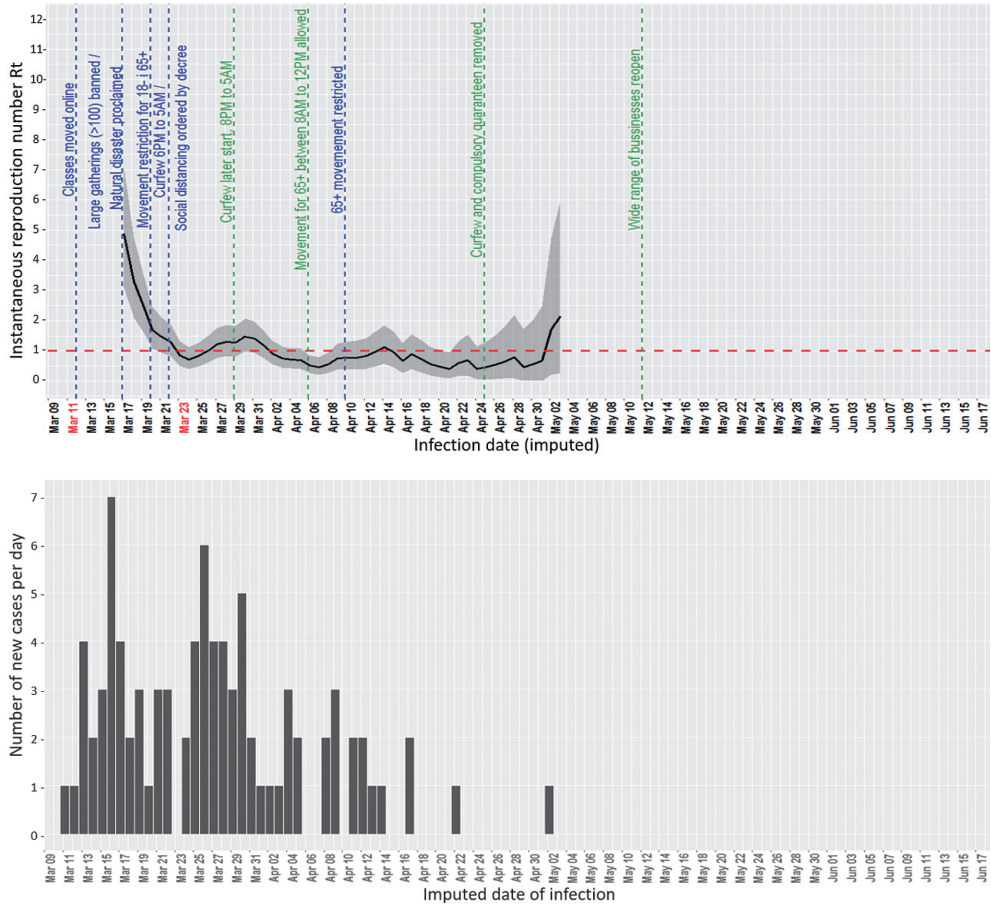
Current growth of infected and optimistic / pessimistic model of the infection spread



No. of days of doubling of the infected ($1/\beta$): 3.34
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 2.72
Herd immunity threshold ($1-1/\beta/\gamma$): 0.63

V. Instantaneous reproductive number R_t and diagram of newly infected per day



VI. A brief overview of the epidemic situation in West Herzegovina Canton

The diagrams describing the dynamics of the spread of infection (section IV) show that after May 13, 2020 the trend of the spreading stopped and that for a long time the R_t number (section V) was between 0 and 1. This situation was the result of the successful implementation of control measures.

Until June 17, 2020 a total of 88 cases of the infection were confirmed. The largest number of the cases refers to the age group of 20-44 years (26.1%), and the most severely affected population is the age group of over 65 years (0.12%). The total morbidity of the population in the reporting period reached 0.09%, and the number of deaths participated with 4.5% of the total number of the infected cases, or 0.004% of the total population. The largest number of the infected was in Široki Brijeg (60). In the coming period, the situation can be expected to worsen due to the

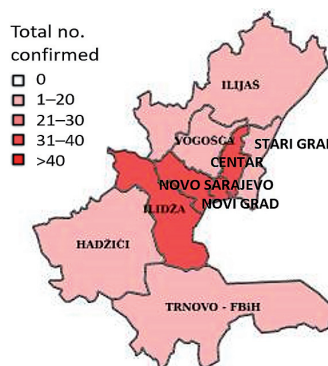
abolition of restrictive control measures, sudden relaxation of the population, and non-compliance with measures related to physical distance, wearing masks and mass gatherings. In this sense, it is necessary to carry out intensified epidemiological surveillance, insisting on the mandatory use of masks, the avoidance of physical contact, physical distance, hygiene measures, restrictions on indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR SARAJEVO CANTON (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
March 20, 2020	The first confirmed case of infection in the place (city / municipality): Novo Sarajevo
June 17, 2020	Total number of cases on the reporting date: 168

II. Spatial distribution of the infected cases by municipalities

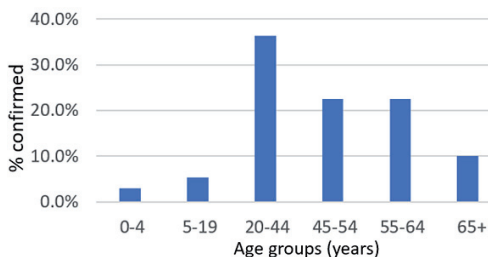


III. Disease statistics

Age and gender structure of the diseased and their distribution by cities / municipalities

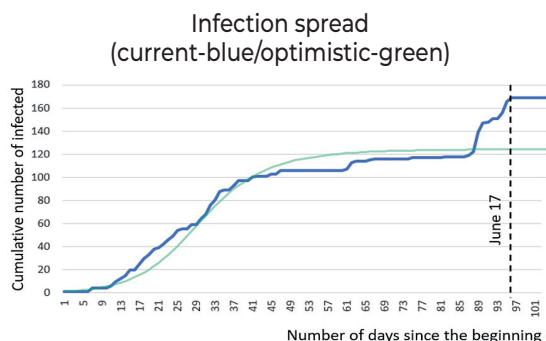
Infected	Number	% of total infected	% of the total population in the group
Total	168	100%	0,04%
0-4 year	5	3,0%	0,02%
5-19 year	9	5,4%	0,01%
20-44 year	61	36,3%	0,04%
45-54 year	38	22,6%	0,06%
55-64 year	38	22,6%	0,07%
65+ year	17	10,1%	0,03%
Male	83	49,4%	0,04%
Female	85	50,6%	0,04%
Deaths	6	3,6%	0,001%

Age structure and prevalence of confirmed cases

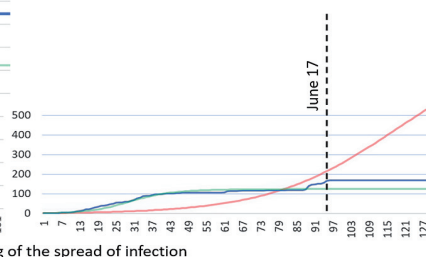


IV. Dynamics of infection spread in Sarajevo Canton

Current growth of infected and optimistic / pessimistic model of the infection spread



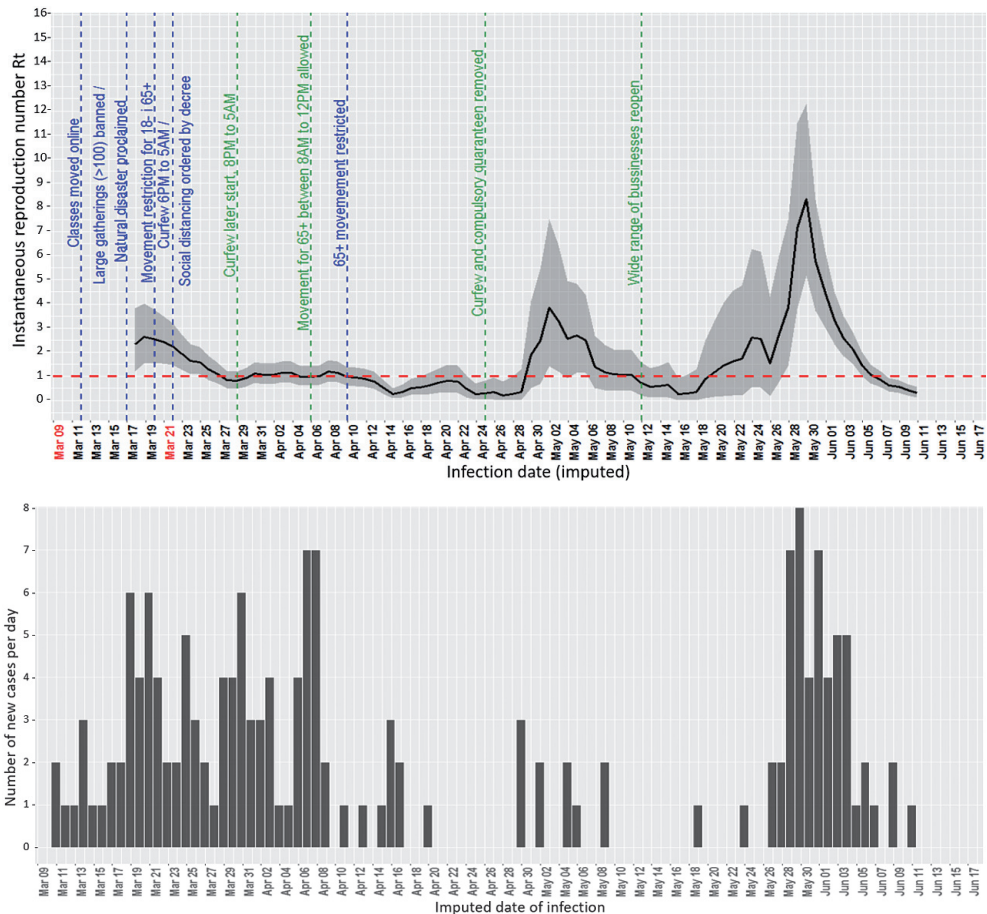
Trend related to possible outcomes (optimistic-green/pessimistic-red)



No. of days of doubling of the infected ($1/\beta$): 3.71
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 2.45
Herd immunity threshold ($1-1/\beta/\gamma$): 0.59

V. Instantaneous reproductive number R_t and diagram of newly infected per day



VI. A brief overview of the epidemic situation in Sarajevo Canton

The diagrams describing the dynamics of the spread of infection (section IV) show that from April 25 to June 10, 2020 the spread of infection was in a declining trend. The R_t diagram (section V) shows that in the period from April 8 to May 8 the reproductive number was below 1 (the date was shifted back by the number of incubation days from the date of symptom onset). This was the result of the successful implementation of control measures, the activities of epidemiological response teams and the discipline of the population. However, after this period, the R_t number was mostly above 1, and on the reporting day it dropped below 1. The growing trend (section IV) from June 10 indicates the possibility of a further increase in the number of the infected cases.

The largest number of the infected refers to the age group of 20-44 years (36.3%), and the most severely affected population is the age group 55-64 years (0.07%). The total morbidity of the population in the reporting period reached 0.04% (168 confirmed cases), and the number of deaths participated with 3.6% of the total number of the confirmed cases, or 0.001% of the total population.

In the coming period, it is necessary to conduct intensified epidemiological surveillance, insisting on the obligatory use of masks, the avoidance of physical contact, physical distance, hygienic measures, restrictions related to indoor gatherings, and other epidemiological measures.

RESULTS OF COVID-19 SPREAD ANALYSIS AND EVALUATION OF THE EPIDEMIC SITUATION FOR CANTON 10 (MARCH 5 – JUNE 17, 2020)

I. Chronology of epidemic events

Date	Epidemic event
April 4, 2020	The first confirmed case of infection in the place (city / municipality): Livno.
April 24, 2020	Beginning of a period of at least two weeks with no new cases. Total number of cases to this date: 41.
June 17, 2020	Total number of cases on the reporting date: 41.

II. Spatial distribution of the infected cases by municipalities

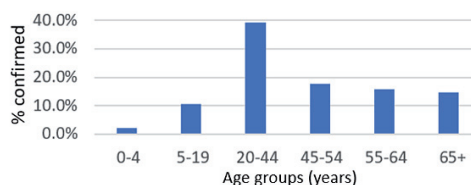


III. Disease statistics

Age and gender structure of the diseased and their distribution by cities / municipalities

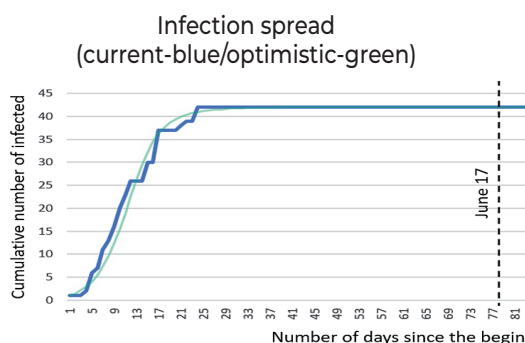
Infected	Number	% of total infected	% of the total population in the group
Total	41	100%	0,05%
0-4 year	0	0,0%	0,00%
5-19 year	3	7,3%	0,02%
20-44 year	17	41,5%	0,06%
45-54 year	6	14,6%	0,05%
55-64 year	5	12,2%	0,05%
65+ year	10	24,4%	0,07%
Male	24	58,5%	0,06%
Female	17	41,5%	0,04%
Deaths	2	4,9%	0,002%

Age structure and prevalence of confirmed cases

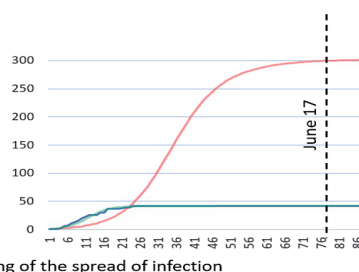


IV. Dynamics of infection spread in Canton 10

Current growth of infected and optimistic / pessimistic model of the infection spread



Trend related to possible outcomes
(optimistic-green/pessimistic-red)



No. of days of doubling of the infected ($1/\beta$): 2.08
No. of days to recover the infected ($1/\gamma$): 9.09

Average growth rate of the infected (β/γ): 4.36
Herd immunity threshold ($1-1/\beta/\gamma$): 0.77

V. Instantaneous reproductive number R_t

The instantaneous reproduction number R_t is not done due to the small number of confirmed cases.

VI. A brief overview of the epidemic situation in Canton 10

The diagrams related to the dynamics of the spread of infection (section IV) show that the trend of the infection spread from April 24, 2020 stopped, which can be attributed to the successful implementation of control measures, the epidemiological response team actions and the discipline of the population.

A total of 41 cases of the infection were confirmed, of which the largest number of infected refers to the age group of 20-44 years (41.5%), and the most severely affected population is over 65 years of age (0.07%). The total morbidity of the population in the reporting period reached 0.05%, with 2 deaths registered (4.9% of the total confirmed cases).

Although the epidemic situation was stable for a long period (54 days without any new confirmed cases), due to the abolition of restrictive epidemiological measures and relaxation of the population, an increase in the infected cases can be expected in the coming period. In this sense, it is necessary to insist on the obligatory use of masks, the avoidance of physical contact, physical distance, hygienic measures, restrictions related to indoor gatherings, and other epidemiological measures.

6. GEOGRAPHIC PRESENTATION OF THE COVID-19 INFECTION SPREAD IN BOSNIA AND HERZEGOVINA FOR PERIODS OF CONTROL MEASURES INTRODUCTION

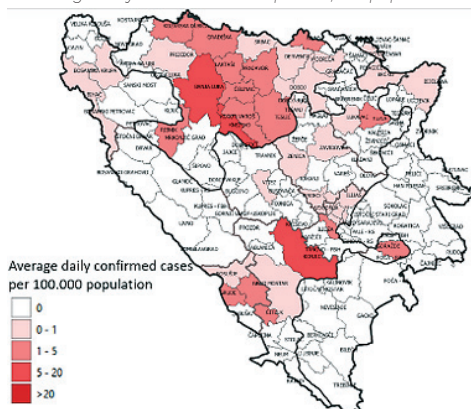
1st period: March 4 – March 29

Control measures:

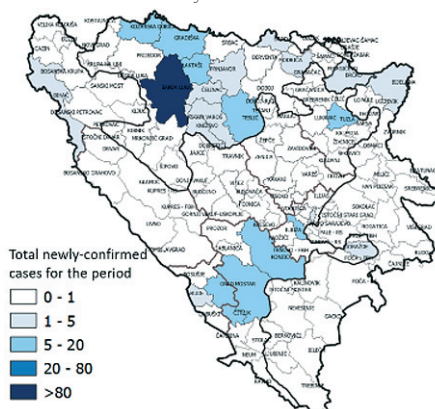
March 16, Republika Srpska (RS): Isolation (14 days) and prescribed control for all passengers entering RS/BiH.

March 20-21: Prohibition of movement for persons under 18 years of age and over 65 years of age in the Federation of Bosnia and Herzegovina (FBiH) and over 65 years in RS. Prohibition of movement of all citizens from 18:00 to 5:00 h in FBiH and from 20:00 to 5:00 h in RS.

Average daily confirmed cases per 100,000 population



Total newly-confirmed cases



In the period from March 4-29 (25 days) from the first confirmed cases in Banja Luka (March 5) and Zenica (March 9) the infection rapidly spread in Bosnia and Herzegovina (BiH), affecting especially the municipalities / cities of Banja Luka, Konjic, Mostar, Čitluk, Ilidža, Tuzla, Laktaši, Teslić, Prijedor, Gradiška and Kozarska Dubica.

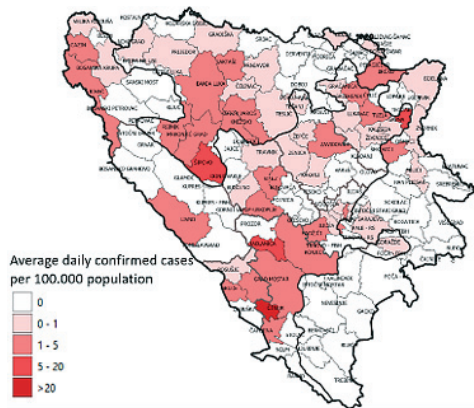
2nd period: March 30 – April 8Control measures:

March 29, FBiH: Ban on the movement of citizens relaxed and was applied from 20:00 to 5:00 h.

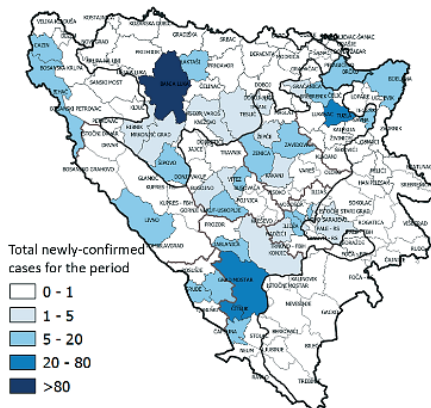
March 31, RS: Allowed movement of citizens over 65 years on Tuesdays and Fridays from 7:00 to 10:00 h.

April 5-6, FBiH/RS: Citizens over 65 years are allowed to move between 8.00 -12.00 h.; Prohibition of movement of all citizens from 18:00 to 5:00 h in FBiH and from 20:00 to 5:00 h in RS.

Average daily confirmed cases per 100,000 population



Total newly-confirmed cases



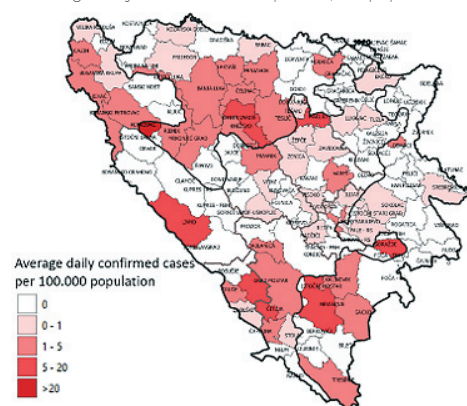
In the period from March 30 to April 8 (10 days) the number of the infected in Banja Luka, Mostar, Čitluk and Tuzla continued to grow, and the infection continued to spread to the municipalities/cities of Cazin, Bihać, Livno, Grude, Široki Brijeg, Čapljina, Jablanica, Brčko, Bjeljina, Šipovo, Sarajevo, Vitez, Zavidovići, Sapna, Srebrenik, Kotor Varoš, Šipovo, Mrkonjić Grad and other parts of BiH.

3rd period: April 9 – April 18Control measures:

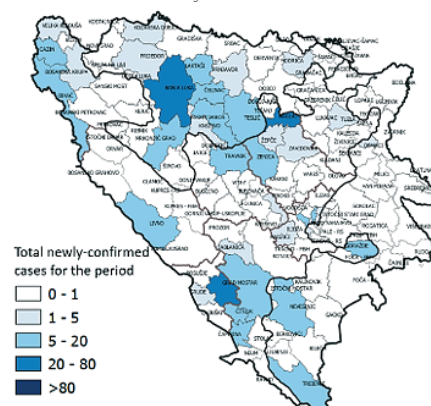
April 9, FBiH: Re-ban on movement for citizens over 65.

April 10, FBiH: Mandatory quarantine for all persons entering BiH.

Average daily confirmed cases per 100,000 population



Total newly-confirmed cases



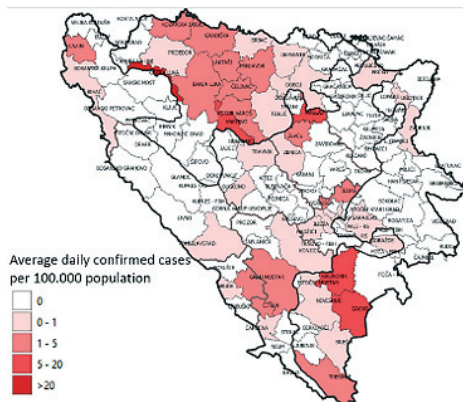
In the period from April 9-18 (10 days) the infection spreads to the municipalities of Gacko, Nevesinje, Kalinovik, Srebrenica, Sokolac, Žepče, Bosanska Krupa, Prnjavor, Čelinac, Modriča, Šamac, Velika Kladuša, Pale, Orašje, Srbac and others. In most municipalities/cities of BiH, the number of cases continued to grow, and a new infection outbreak appeared in Maglaj.

4th period: April 19 – April 28

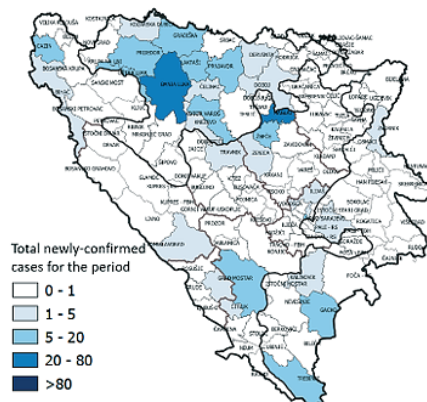
Control measures:

April 24, FBiH: Movement ban lifted: citizens over 65 can go out on Mondays, Wednesdays and Fridays; citizens under 18 vice versa. Quarantine for arrivals from abroad abolished.

Average daily confirmed cases per 100,000 population



Total newly-confirmed cases



In the period from April 19-28 (10 days) the spread of infection slowed down. In some parts of BiH, the first signs of action of control measures were noticeable. In the municipalities of Posavina, Tuzla and Bosnia-Podrinje Canton, the spread of infection was stopped.

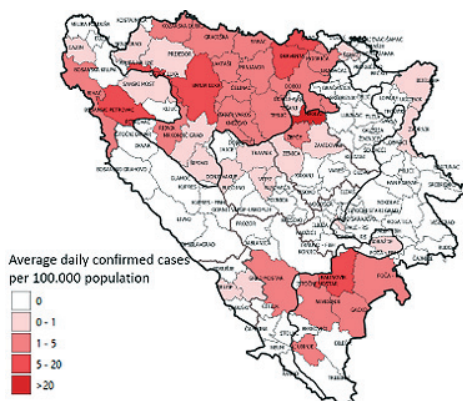
5th period: April 29 – May 8

Control measures:

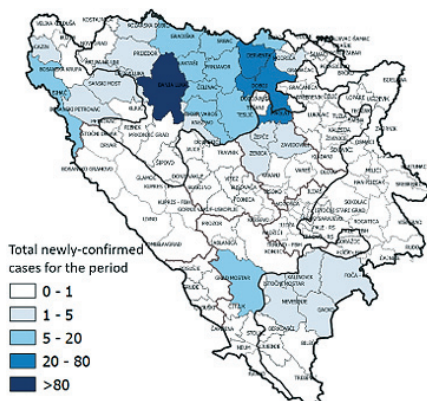
May 5, RS: Relaxed movement ban, applied from 22:00 - 05:00 h; Citizens over the age of 65 were allowed to move from 7:00 to 10:00 h.

May 6, RS: Prohibition of movement for all citizens on May 6.

Average daily confirmed cases per 100,000 population



Total newly-confirmed cases



In the period from April 29 to May 8 (10 days), the spread of infection in the Federation of Bosnia and Herzegovina (FBiH) continued to decline. In the municipalities of Central Bosnia Canton, Canton 10, Sarajevo Canton and the Brčko District, the spread of infection was stopped. In the cities/municipalities of Republika Srpska (RS), and especially in Banja Luka, Derventa and Doboj, the number of the newly infected was increasing.

6th period: May 9 – May 18

Control measures:

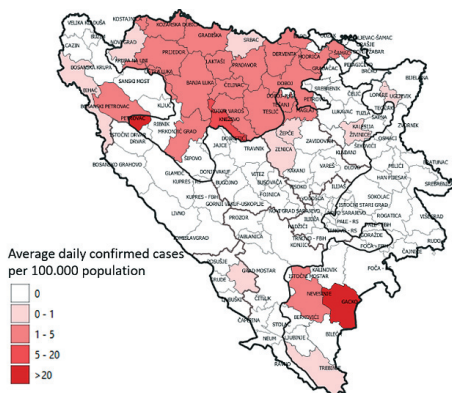
May 11, RS: Implementation of surveillance of persons entering BiH through border crossings in RS.

May 14, RS: Prohibition of organizing prom nights for primary and secondary schools.

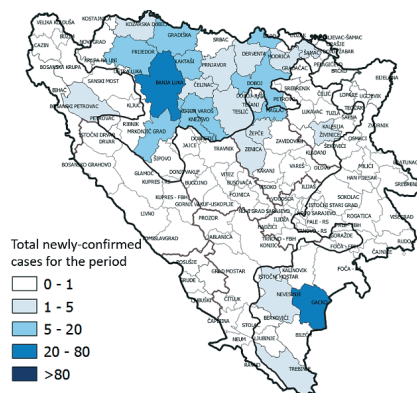
May 12, FBiH: Approval of kindergartens, driving schools, dental practices, provision of catering facilities and hotels (outdoors), and public transport.

May 14, FBiH: Extension of measures banning the movement of citizens from 20:00 – 5:00 h.

Average daily confirmed cases per 100,000 population



Total newly-confirmed cases



In the period from May 9-18 (10 days) the number of the newly infected in RS and FBiH was decreasing. In the Herzegovina-Neretva Canton, the spread of infection was stopped. New cases of infected people appeared in Živinice, city in the Tuzla Canton.

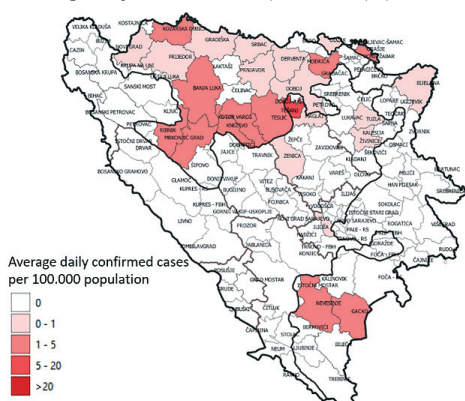
7th period: May 19 – May 28.

Control measures:

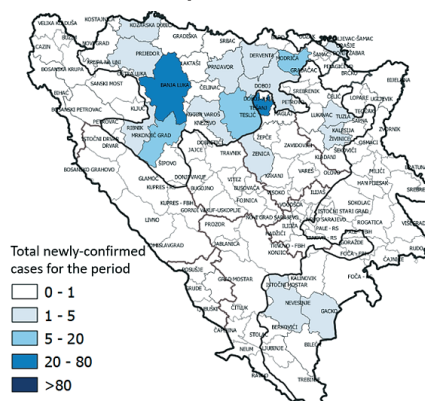
May 25, RS: Prohibition of public gatherings in groups of more than 50 people in a public place; approved work with swimming pools, "wellness" and spa centers.

May 27, FBiH: Prohibition of the use of hookahs in catering facilities.

Average daily confirmed cases per 100,000 population



Total newly-confirmed cases



In the period May 19-28 (10 days), the number of the infected people in the RS, as well as in the FBiH, was decreasing. In the West Herzegovina Canton, the spread of infection stopped. The number of newly infected began to grow in Tešanj.

8th period: May 29 – June 7

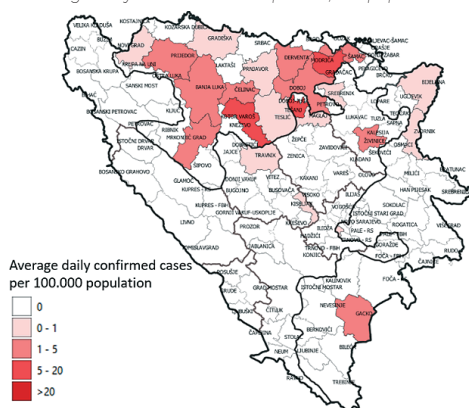
Control measures:

May 30, FBiH: Cancellation of all public gatherings in FBiH; Order on the use of protective equipment and respect for physical distance of at least 2m.

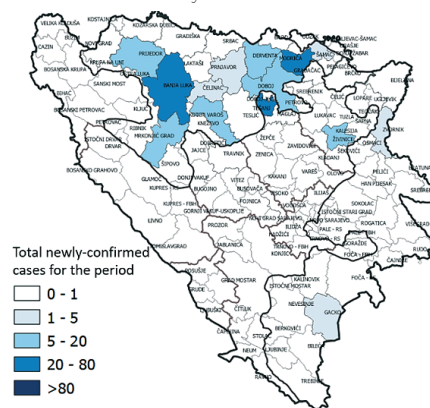
May 31, FBiH: Decision on the termination of the state of an accident caused by a virus Covid-19.

June 3, RS: Amended measures for the operation of shopping centers and shops.

Average daily confirmed cases per 100,000 population



Total newly-confirmed cases



In the period from May 29 to June 7 (10 days), the number of daily infections in Republika Srpska maintained a decreasing trend. In the Federation of BiH, there was no significant increase in the number of the infected except in the municipalities/cities of Živinice, Srebrenik, Maglaj, Tešanj and Travnik.

9th period: June 8 – June 17

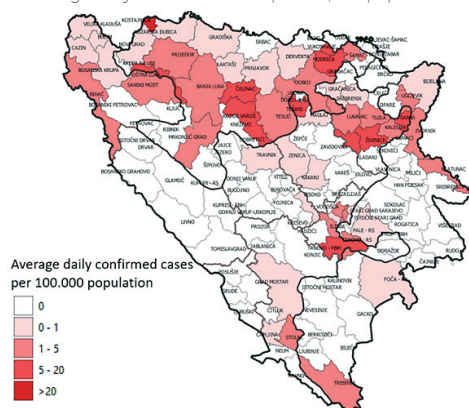
Control measures:

June 8, RS: Working hours are limited to catering facilities from 6 am to 11 pm; ban on competitive activities for sports organizations

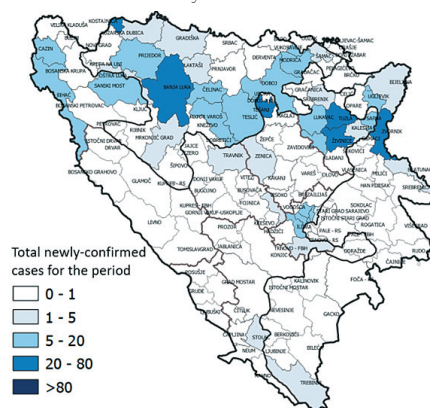
June 12, FBiH: Approval for proclamation of an infectious disease epidemic in Sarajevo Canton and Tuzla Canton

June 14, FBiH: Implementation of enhanced monitoring of the implementation of measures against COVID-19

Average daily confirmed cases per 100,000 population



Total newly-confirmed cases



In the period from June 8-17 (10 days) the number of new infected cases in FBiH began to grow rapidly. In particular, a higher increase in confirmed cases was recorded in Tuzla Canton, Una-Sana Canton and Sarajevo Canton. The growth of newly infected people also increased in Republika Srpska. In addition to further growth of the confirmed cases in a number of municipalities/cities from the previous period, the number of infected was registered in Kostajnica, Bijeljina, Zvornik, Stolac, Trebinje, Bratunac, Bužim, Novi Grad, Srbac, Ugljevik and Sanski Most.

7. BRIEF DESCRIPTION OF THE EPIDEMIC SITUATION IN BOSNIA AND HERZEGOVINA FROM JUNE 17 – JULY 7, 2020

Based on the diagrams shown in Figure 7.1, it can be concluded that in the period until May 18 there was a decreasing trend in the number of the infected people per day in Bosnia and Herzegovina, and that the R_t number was below 1, which indicated that the number of the diseased was declining. From May 19 this trend changed and the number of the infected began to grow. The number of confirmed cases increased significantly (by 1184 new cases) in the decade from June 18 to June 27, 2020, and this trend continued with a slightly lower intensity in the following period (June 28 – July 7, 2020) (Table 7.1).

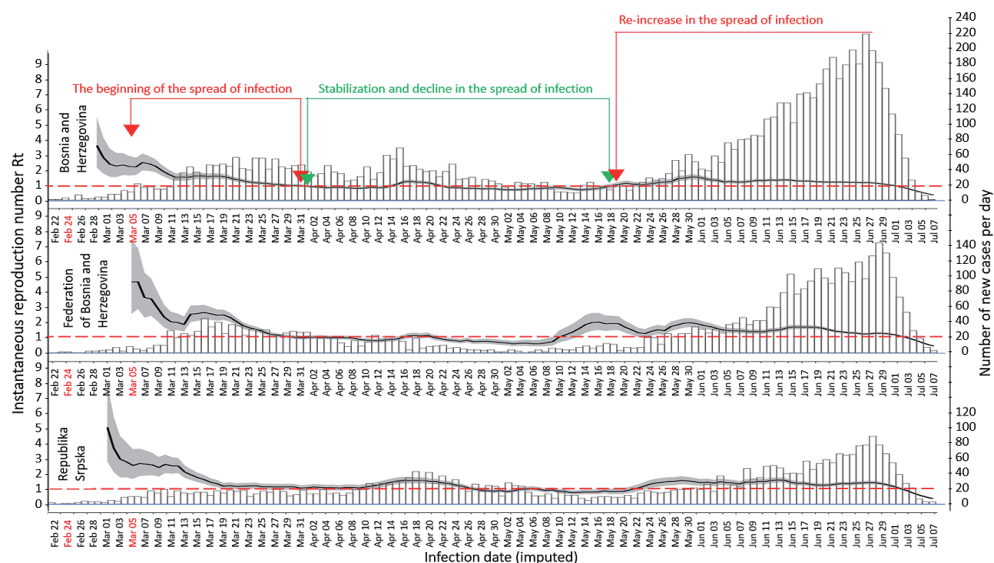


Figure 7.1 Diagrams for R_t number and number of newly infected cases per day until July 7, 2020 in Bosnia and Herzegovina, the Federation of BiH and the Republika Srpska, with different periods of infection spread

The situation continues to deteriorate due to the relaxation of the population and non-compliance with precautionary measures. This was further contributed to by careless gatherings of citizens, and a sudden relaxation of measures related to the operation of catering facilities, where the younger and middle-aged population began to “mix” intensively. In just four weeks since the relaxation of epidemiological measures related to restrictions on the movement of citizens, there have been dozens of new cases confirmed daily, mostly of middle-aged people. In Table 7.1 this increase is shown using the daily average for the periods June 8-17, June 18-27 and June 28 – July 7, 2020 for Republika Srpska, the Federation of BiH, Brcko District and the entire country.

Table 7.1. Review of the increase in the number of confirmed cases and deaths in the period from June 7 – July 7, 2020

Administrative Unit of BiH	Daily average of confirmed for the period			Daily average deaths for the period			% increase of confirmed between periods		% increase in deaths between periods	
	I 8.6. - 17.6.	II 18.6. - 27.6.	III 28.6. - 7.7.	I 8.6. - 17.6.	II 18.6. - 27.6.	III 28.6. - 7.7.	II / I	III / II	II / I	III / II
Republika Srpska	20	42	53	0.2	0.4	1.3	212%	126%	208%	325%
Federation of BH	24	56	92	0.6	0.8	1.6	235%	164%	138%	200%
Brcko District of BH	0	1	1	0.0	0.1	0	/	/	/	/
Bosnia and Herzegovina	44	99	146	0.8	1.3	2.9	225%	147%	166%	223%

The number of infected cases in Bosnia and Herzegovina, in the decade June 18-27 increased by 225% (more than double) compared to the previous decade. The previous ratio between the decades was 162% (the average rate of diseased people increased by 63%). In the next decade, from June 28 – July 7, this ratio was lower, i.e. it was 147%, but the death rate increased to 223% (by 57%). After July 7, the number of the infected and deaths continues to grow and with this trend a greater deterioration of the situation could be expected.

8. CONCLUSION

The Epidemic Location-Intelligence System (ELIS) infrastructure for the collection, centralization and analysis of epidemic data has been established, the system is operational and data is collected from different sources for different administrative levels of the public health organization in Bosnia and Herzegovina. This data is biostatistically processed and analyzed, and the results of the analysis are reported using the developed modeling and geovisualization techniques in ELIS.

Based on the presented results of the data analysis until June 17, 2020 three periods may be recognized that differ in their epidemiological characteristics related to the spread of COVID-19 infection in Bosnia and Herzegovina (Figure 7.1):

- period of the beginning of the infection spread (March 5-31, 2020) when the R_t number was above 1;
- period of stabilization and gradual reduction of the spread (from April 1 to May 18) when the R_t number was generally below 1, and
- period of renewed spread of infection (from May 19 to June 17) when the R_t number oscillated above 1.

The characteristics of the spread of infection in these periods were correlated with the adopted restrictive and relaxing epidemiological measures.

From June 17 to mid-July (in the period after the reporting time window described in this publication), the situation began to deteriorate due to sudden relaxation of the population after the reduction of the introduced measures. A special impact on the deterioration was the mass arrival of BiH citizens from the diaspora in the last week of May, who entered the country without epidemiological surveillance. In this context, a measure could be introduced that all persons entering BiH must have a negative PCR test for SARS-CoV2 not older than 72 hours.

After July 7, the number of infected cases and deaths continues to grow, and with this trend, a greater deterioration of the situation could be expected. The number of confirmed cases has significantly increased in more densely populated municipalities

of Republika Srpska, as well as in Tuzla, Zenica-Doboj, Una-Sana and Sarajevo Canton. This has prompted entity governments to make new recommendations and consider introducing more restrictive measures and tighter epidemic surveillance.

Due to the greater concentration of the population indoors, during the autumn period, a greater spread of the epidemic can be expected, for which it should be prepared. In this regard, special attention should be paid to improving hospital epidemiological surveillance and improving hospital capacities.

Although the COVID-19 epidemic is accelerating its spread in BiH, it has not yet grown into an endemic, and it is possible to slow down further growth of the disease with the appropriate actions, a stricter implementation of epidemiological measures, and the control of their conducting.

The implementation against epidemic measures is currently the responsibility of the State, entity, cantonal institutions, local communities and each individual. Competent institutions at various levels of government have issued a number of orders and recommendations related to the measures of physical distance, hygiene, mass gathering and use of various public and private services.²³ In order to monitor their effects more effectively and to control the rapidly changing situation, it is necessary to improve the system of epidemiological surveillance.

Over the past four months, since the beginning of the pandemic, the surveillance system in Bosnia and Herzegovina has proved to be very complex, slow and sensitive to human error. It is necessary to establish a fast, simple, flexible, sensitive and centralized electronic surveillance, which would gather information in a short time and in one place. It is very important that this epidemiological surveillance is coordinated between the entities (since there is no common Ministry of Health). Such a monitoring system would, among other measures, prevent future lockdown (measures of extreme isolation and closure of local areas).

In the context of realized virological research, it should be noted that a wide network of trained, verified, virological molecular laboratories for the diagnosis of SARS CoV 2 infection is being formed in Bosnia and Herzegovina. Already existing laboratories are being modernized, new ones are being opened, all with the aim of increasing efficiency and timely diagnosis and detection of the source of infection.

On the "One Health" platform, cooperation has been established between human and veterinary laboratories in the field of virus analysis and its ecology.

The VFUNSA Molecular Genetics and Forensic Laboratory isolates viruses from samples collected from human and animal samples. In this way, preconditions are created for their further genetic and antigenic testing, in order to establish genetic diversity of the virus circulating in Bosnia and Herzegovina, examine its immunogenicity and detect possible mutations.

In this regard, in addition to virus sequencing activities, the following should be carried out:

- a) research aimed at examining the ability of existing or experimental antiviral drugs to treat or prevent SARS CoV-2 infection;

- b) research aimed at the development / contribution to the development of effective vaccines;
- c) research of biological characteristics and pathogenesis of isolates aimed at determining different ways of virus transmission from one host to another, factors that may affect the course and severity of the disease in infected persons (replication success in different organ systems and tissues), and
- d) research on the manner of virus transmission from one host to another.

Since the laboratory has a number of very potent sequencing samples, and all previous activities on virus isolation and sequencing were carried out exclusively using the material, technical and financial resources of VFUNSA, the support of BiH governmental institutions is necessary for the continuation of the mentioned research activities. Also, the intensity and dynamics of planned project activities on further development and application of the Epidemic Location Intelligence System depend on this support, as well as further research important for creating preconditions for a more efficient response to future emergencies caused by pathogens, which ultimately contributes to strengthening national biosafety.

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APPENDICES

APPENDIX 1: HOSPITAL EPIDEMIC SURVEILLANCE QUESTIONNAIRE

Proposal of a questionnaire intended for hospital epidemic surveillance prepared by the project team for validation and standardization of data collection for hospitalized cases:

ANKETNI UPITNIK ZA HOSPITALIZIRANE OSOBE S COVID-19

I. PODACI O ANKETARU				
1. Ime ustanove				
2. Ime osobe koja je vršila nadzor:		3.a Telefon:	3.b Email:	
4. Datum izvještavanja				
II. DEMOGRAFSKI PODACI				
5. Ime i prezime:				
6. Spol:	Muški ☐	Ženski ☐	6.a. Datum rođenja:	6.b. Godine starosti:
7. Broj telefona			7b. Email adresa	
8. DZ kojem pripada:			8b. Ljekar kojem pripada:	
9. Broj kartona:				
10. Ime roditelja/staratelja				
11. Adresa boravka			11. a.Grad, poštanski broj	
III. PODACI O POTENCIJALNOJ IZLOŽENOSTI VIRUSU				
12. Da li je osoba 14 dana pred početak simptoma boravila u inostranstvu ?			Da ☐ Ne ☐ Nepoznato ☐ Ako da, naziv zemlje	
13. Da li je osoba 14 dana pred početak simptoma putovala u druge kantone ili opštine (entitet)?			Da ☐ Ne ☐ Nepoznato ☐ Ako da, naziv kantona/opštine	
14. Da li je osoba boravila u kolektivnom smještaju prije pojave prvih simptoma? (npr . starački dom, izbjeglički kamp i sl.)?			Da ☐ Ne ☐ Nepoznato ☐ Ako da, naziv i adresa.....	
15. Da li je osoba zdravstveni radnik?			Da ☐ Ne ☐ Nepoznato ☐ Ako da, struka.....naziv i mjesto	
16. Da li je osoba 14 dana pred početak simptoma boravila u zdravstvenoj ustanovi s potvrđenim slučajevima COVID-19 (kao pacijent, radnik ili posjetilac)?			Da ☐ Ne ☐ Nepoznato ☐ Ako da, naziv i adresa..... Sprat i broj sobe..... Dani boravka	
17. Da li je osoba imala kontakt s drugom osobom u bolnici s potvrđenim COVID-19 testom? Da ☐ Ne ☐ Nepoznato ☐			Ako da, druga osoba je: Zdravstveni radnik Pacijent Posjetilac Drugo	
III. KLINIČKI PODACI				
18. Datum početka prvih simptoma:	 Nepoznato	18 a. Opis početka simptoma:		☐ Postepen početak ☐ Nagli početak

19. Visina/ težina	19a. Visok.....cm/	19b. Težak.....kg	Nepoznato ☐
20. Da li je osoba trudnica?	Da ☐ (sedmica trudnoće.....) Ne ☐ Nije relevantno ☐		
21. Da li je osoba primljena direktno (npr. iz doma zdravlja) u bolnicu?	Da ☐ (naziv.....) Ne ☐ Nepoznato ☒		
22. Ako se radi o bolničkom transferu, ime bolnice iz koje je osoba prebačena u navedenu			
23. Da li je osoba razvila upalu pluća?	Da ☐	Ne ☐	Nepoznato ☐
	Opis.....		
24. Da li osoba ima patološki Rtg nalaz?	Da ☐	Ne ☐	Nepoznato ☐
	Opis.....		
25. Da li osoba ima patološki CT nalaz?	Da ☐	Ne ☐	Nepoznato ☐
	Opis.....		
26. Da li je osoba razvila akutni respiratorni sindrom?	Da ☐	Ne ☐	Nepoznato ☐
	Opis.....		
27. Da li diferencijalna dijagnoza upućuje i na drugo oboljenje?	Da ☐	Ne ☐	Nepoznato ☐
	Opis.....		
28. Da li je osoba primljena u jedinicu za intenzivnu njegu?	Da ☐	Ne ☐	Nepoznato ☐
	Opis.....		
29. Datum prijema	Datum otpusta		
30. Da li je pacijent na mehaničkoj ventilaciji	Da ☐	(broj dana.....) Ne ☐	Nepoznato ☐
31. Ishod	Preživio ☐ Umro ☐ (datum.....)		
32. Simptomi	Da ☐ (ako da upisati datum početka..... i završetka simptoma.....) Ne ☐ Nepoznato ☐ Prvi simptom.....		
☐ Temperatura od 37 do 38 °C ☐ Temperatura >38 °C ☐ Suhi kašalj ☐ Bolovi u grlu ☐ Malaksalost ☐ Otežano disanje	☐ „Curenje“ iz nosa ☐ Dijareja (>3 stolice za 24 sata) ☐ Povraćanje ☐ Bolovi u mišićima ☐ Gubitak mirisa ☐ Gubitak okusa ☐ Neurološki simptomi Ako da, navesti koji.....		
33. Prisutnost edema	☐ Da (datum početka.....) ☐ Ne ☐ Ne znam		
34. Da li je pacijent prošao bolničku trijažu	☐ Da (datum.....) ☐ Ne ☐ Ne znam		
35. Ako da, rezultat trijaže	☐ Pozitivan ☐ Negativan ☐ Ne znam		
36. Da li osoba ima hronično oboljenje	Da ☐	Ne ☐	Nepoznato ☐
	Ako da, navesti koje	Da	Ne
	Hronična oboljenja pluća	☐	☐
	Diabetes Melitus	☐	☐
	Kardiovaskularne bolesti	☐	☐
	Hronična bubrežna oboljenja	☐	☐
	Hronična oboljenja jetre	☐	☐
	Imunokompromitovana stanja	☐	☐
	Neurološka/neurorazvojna	☐	☐
	Ako da, koja.....	☐	☐
	Druga hronična stanja	☐	☐
	Ako da, navesti koje.....	☐	☐

		Pušač Bivši pušač Drugo.....	☐ ☐	☐ ☐
V. TERAPIJA				
37. Navesti terapiju				
Remdesivir	☐ Da	(početak.....kraj.....)	☐ Ne	☐ Ne zna
Kortikosteroidi	☐ Da	(početak.....kraj.....)	☐ Ne	☐ Ne znam
Hidroksiklorokin	☐ Da	(početak.....kraj.....)	☐ Ne	☐ Ne znam
Klorokin fosfat	☐ Da	(početak.....kraj.....)	☐ Ne	☐ Ne znam
Lopinavir/ritonavir	☐ Da	(početak.....kraj.....)	☐ Ne	☐ Ne znam
Thalidomide	☐ Da	(početak.....kraj.....)	☐ Ne	☐ Ne znam
Heparin	☐ Da	(početak.....kraj.....)	☐ Ne	☐ Ne znam
Tocilizumab	☐ Da	(početak.....kraj.....)	☐ Ne	☐ Ne znam
Rekonvalescentna plazma	☐ Da	(početak.....kraj.....)	☐ Ne	☐ Ne znam
Drugo				
VI. LABORATORIJSKI PODACI				
38. Testiran na COVID-19:	☐ Da ☐ Ne ☐ Nepoznato	39 a.Vrsta uzorka: 39 b. Datum prikupljanja 39 c. Datum testiranja Naziv lab. Nazofaringealni trag Orofaringealni trag Drugo.....		
39. Rezultati testa na SARS-CoV-2	☐ Pozitivan ☐ Negativan ☐ Na čekanju			
40. Testiran na Panel respiratornih virusa	☐ Da ☐ Ne ☐ Nepoznato			
41. Ukoliko je odgovor pozitivan, unesite na koje viruse i rezultat:				
42. NAPOMENA				
Upišite dodatne komentare ako imate.				

LIST OF ABBREVIATIONS

ACE2	Angiotensin-Converting Enzyme 2 receptor
AJAX	Asynchronous JavaScript And XML
ANUBiH	Academy of Sciences and Arts of Bosnia and Herzegovina
API	Application Programming Interface
BiH	Bosnia and Herzegovina
BSL	BioSafety Level / biosigurnosni nivo
CPE	Cytopathic Effect / citopatogeni efekat
CT	Computerized Tomography
ECDC	European Centre for Disease Prevention and Control
ELIS	Epidemic Location Intelligence System
EU	European Union
FBiH	Federation Bosnia and Herzegovina
GIS	GeoInformation System
GISAID	Global Initiative on Sharing All Influenza Data
HIT	Herd Immunity Treshold
HKU	Hong Kong University
HTTP	Hypertext Transfer Protocol
MERS-CoV	Middle East Respiratory Syndrome – coronavirus
NAAT	Nucleic Acid Amplification Tests
PBS	Phosphate-Buffered Saline
RS	Republika Srpska
RT-qPCR	Reverse Transcriptase – Quantitative Polymerase Chain Reaction
SARS-CoV	Severe Acute Respiratory Syndrome – coronavirus
SIR	Susceptible / Infectious / Recovered
VFUNSA	Faculty of Veterinary Medicine, University of Sarajevo
VTM	Viral Transport Medium
WHO	World Health Organisation

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