https://doi.org/10.31891/csit-2023-3-7
UDC 004.9

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# METHOD OF CREATING AN INFORMATION SYSTEM FOR MONITORING INFECTIOUS PATIENTS

*In the context of the COVID-19 pandemic, infectious disease information systems are widely used and promoted to prevent the spread of the pandemic (mainly in the form of mobile applications). Many countries have offered their apps to improve contact tracing and thus reduce the number of infections. However, the level of adoption of such applications has been and remains relatively low, which, obviously, given their massive use and effectiveness, has been largely influenced by issues related to privacy and anonymity, as well as the perception of potential users of the price-benefit ratio. Thus, the task of creating information systems for monitoring infectious patients is still relevant today. Therefore, our study is devoted to the development of a method and an information system for monitoring infectious patients.*

*The article develops a method for creating an information system for monitoring infectious patients, which, unlike the known ones, is based on intelligent analysis of data on the geolocation of patients and contact persons, and provides the ability to design an information system for controlling infectious patients. The purpose of the information system for monitoring infectious patients is to prevent the spread of epidemics and pandemics by tracking patient contacts and reducing the number of infections. The tasks of the information system for monitoring infectious patients are to track the self-isolation of infectious patients and their contacts, identify the most "infected" buildings, districts, cities, etc. based on intelligent analysis of data on infectious patients and their contacts.*

*The designed mobile-oriented information system for monitoring infectious patients can be used to prevent the spread of the pandemic by tracking contacts and reducing the number of infections. The design of screen forms, reports, implementation, testing and commissioning of the information system for monitoring infectious patients will be carried out by the authors in the course of their further research.*

*Keywords: information system, control of infectious patients, method of creating an information system, data mining.*

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# МЕТОД СТВОРЕННЯ ІНФОРМАЦІЙНОЇ СИСТЕМИ КОНТРОЛЮ ЗА ІНФЕКЦІЙНИМИ ХВОРИМИ

*В контексті пандемії COVID-19 інформаційні системи контролю за інфекційними хворими широко використовуються і просуваються для запобігання поширенню пандемії (в основному, у вигляді мобільних додатків). Багато країн запропонували свої додатки з метою покращити відстеження контактів і таким чином зменшити кількість випадків інфікування. Однак рівень впровадження таких додатків був і залишається відносно низьким, на що, очевидно, враховуючи їх масове використання та ефективність, значною мірою вплинули питання, пов'язані з конфіденційністю та анонімністю, а також сприйняття потенційними користувачами співвідношення ціни та вигоди. Отже, задача створення інформаційних систем контролю за інфекційними хворими є актуальною і в наш час. Відтак наше дослідження присвячене розробленню методу та інформаційної системи контролю за інфекційними хворими.*

*У статті розроблено метод створення інформаційної системи контролю за інфекційними хворими, який, на відміну від відомих базується на інтелектуальному аналізі даних про геолокації хворих та контактних осіб, та забезпечує можливість проєктування інформаційної системи контролю за інфекційними хворими. Метою інформаційної системи контролю за інфекційними хворими є запобігання поширенню епідемії та пандемії шляхом відстеження контактів хворих та зменшення кількості випадків інфікування. Задачі інформаційної системи контролю за інфекційними хворими: відстеження перебування на самоізоляції інфекційних хворих та їхніх контактних осіб, визначення найбільш «заражених» будинків, районів, міст, тощо на основі інтелектуального аналізу даних про інфекційних хворих та їхніх контактних осіб.*

*Спроєктована мобільно-орієнтована інформаційна система контролю за інфекційними хворими може використовуватись для запобігання поширенню пандемії шляхом відстеження контактів і зменшення кількості випадків інфікування. Проектування екранних форм, звітів, реалізація, тестування та введення в дію інформаційної системи контролю за інфекційними хворими будуть виконуватись авторами під час їх подальших досліджень.*

*Ключові слова: інформаційна система, контроль за інфекційними хворими, метод створення інформаційної системи, інтелектуальний аналіз даних.*

## Introduction

An epidemic is a massive spread of an infectious disease among the population of a given area over a short period of time. Despite all scientific advances, the spread of infectious diseases continues to pose a significant threat to the health and prosperity of our society.

Humanity has long suffered from epidemics (smallpox, plague, cholera, malaria, typhoid, diphtheria, etc.) and for a long time could not withstand the high mortality rate, which sometimes reached 90% of the population of

the epidemic-affected region. Since ancient times, in addition to quarantine, the fight against epidemics has included the creation of contagious barracks where patients were isolated and treated, the involvement of additional medical personnel, disinfection of territories and housing, the deployment of sanitary posts, and the provision of disinfectants to the population. However, even then, the problem of effective organization of management and control over the actions of quarantine and medical services on the scale of both individual territories and the entire state was acute [1].

Currently, protecting the population from infectious diseases is one of the priority areas of activity of executive authorities and local governments. In the area of protection of the population from infectious diseases, the Cabinet of Ministers of Ukraine develops and implements relevant state targeted programs, provides funding and logistical support to healthcare institutions, institutions and facilities of the State Sanitary and Epidemiological Service, enterprises, institutions and organizations involved in activities and works related to the elimination of epidemics, coordinates these activities and works, and resolves other issues within the powers defined by law. At the same time, in this area, local governments ensure the implementation of preventive and anti-epidemic measures in the territories of settlements, in places of mass recreation and recreational areas, as well as work to eliminate epidemics and outbreaks of infectious diseases, and resolve issues of financial and logistical support for these measures and work. The specially authorized central executive body on health care in the field of protection of the population from infectious diseases develops, approves and enacts sanitary and anti-epidemic rules and regulations, methods of examination and treatment of patients, diagnosis and prevention of infectious diseases, and other regulatory acts [2].

The fundamentals of Ukrainian healthcare legislation regulate the prevention of infectious diseases dangerous to the public. Thus, persons who carry infectious diseases dangerous to the public are excluded from work and other activities that may contribute to the spread of infectious diseases and are subject to medical supervision. In respect of certain particularly dangerous infectious diseases, mandatory medical examinations, preventive vaccinations, treatment and quarantine measures may be carried out in accordance with the procedure established by the laws of Ukraine. At the same time, persons suffering from infectious diseases or being bacterial carriers are obliged to take measures recommended by medical professionals to prevent the spread of infectious diseases, comply with the requirements and recommendations of medical professionals regarding the procedure and conditions of treatment, comply with the operating hours of healthcare facilities and scientific institutions where they are treated, and undergo the necessary medical examinations and examinations within the established time limits [2].

Immunization of the population plays a significant role in reducing the level of infectious diseases, but it is possible and effective only for the prevention of known diseases. Thus, in 2019-2021, humanity faced the new COVID-19 virus, which it was completely defenseless against due to its novelty and the lack of a vaccine against this virus. Traditional epidemiological surveillance of infectious diseases failed to warn health authorities in time to intervene and mitigate and control COVID-19 before the epidemic turned into a pandemic. To stop the spread of COVID-19, humanity was forced to resort to strict quarantine measures (self-isolation, strict control of patients and their contacts, etc.)

Information systems and technologies help to monitor compliance with quarantine measures. For example, in Ukraine, compliance with quarantine measures was monitored using the Vdoma electronic service or the installed and activated mobile application of the Vdoma electronic service of the Unified State Web Portal of Electronic Services [3]. This service/application was used to counteract the spread of COVID-19 and monitor self-isolation and was mandatory for Ukrainians, foreigners and stateless persons crossing the state border to enter Ukraine. Upon arrival at the place of self-isolation, the user of the system/application was obliged to confirm his/her arrival and send a photo, and the user's geolocation was recorded when sending the photo. During self-isolation, the user was allocated 2 hours per day for personal needs. During this time, it was possible to leave the place of self-isolation to visit places of trade in food, hygiene products, medicines, and medical devices located at a distance of no more than 2 kilometers from the place of self-isolation [4].

In the paper [5], the heterogeneous network-based epidemic model with positive and negative information is proposed. This model considered three time-varying control schemes for containing the contact infection rate and enhancing the implementation rate of positive information for reducing the number of infected and the cost of control.

The surveillance and early warning system is the basis of public health emergency prevention and control. Authors of [6] attempted to develop a new pattern of integrated surveillance and early warning system for the emerging infectious disease.

The paper [7] designed the “detection-service-mobile” three-terminal geographic information system for realizing the control of diagnostic instruments and the comprehensive management of data. Machine learning is used to marked the detection results on the mobile terminal map to realize the visual display of the positive results of nucleic acid amplification detection and the early warning of infectious diseases.

The paper [8] proposed the intelligent COVID-19 early warning system using Twitter data with novel machine learning methods – the natural language processing (NLP) pre-training technique, fine-tuning BERT as a Twitter classification method. In addition, authors of [8] implemented a COVID-19 forecasting model through a Twitter-based linear regression model to detect early signs of the COVID-19 outbreak. Also, in [8] the expert system, an early warning web application based on the proposed methods were developed.

Authors of [9] proposed the principles for the development of an intelligent information system for decision-making support for epidemiological diagnostics, which is based on the mathematical tools for analyzing morbidity

data, as well as modeling of epidemic processes.

The paper [10] presented the inferring disease data management system with blockchain and machine learning. This is a solution for organizing, sharing and analyzing the disease data with trusted, privacy-preserving and interoperable methodologies to improve the outreach, time and cost-effectiveness for disease-control and treatment interventions.

So, in the context of the COVID-19 pandemic, infectious disease information systems are widely used and promoted to prevent the spread of the pandemic (mainly in the form of mobile applications). Many countries have offered their apps to improve contact tracing and thus reduce the number of infections. However, the level of adoption of such applications has been and remains relatively low, which, obviously, given their massive use and effectiveness, has been largely influenced by issues related to privacy and anonymity, as well as the perception of potential users of the price-benefit ratio. Thus, the task of creating information systems for monitoring infectious patients is still relevant today. Therefore, our study is devoted to the development of a method and an information system for controlling infectious patients. [11].

Thus, the task of creating information systems for monitoring infectious patients is still *relevant* today. Therefore, our *study is devoted* to the development of a method and an information system for monitoring infectious patients.

**Information System for Monitoring Infectious Patients**

The use of effective methods and tools for creating an information system and the correct construction of its creation technology can significantly reduce costs and shorten development time, ensuring the quality of the data processing system that meets the requirements of users. When creating an information system, a whole range of methods and tools are used to develop it. An information system development method is a way of creating an information system supported by appropriate design tools. The means of creating an information system are standard design solutions, application packages, standard projects or tools for designing an information system [12, 13].

Thus, the *method of creating an information system for monitoring infectious patients* consists of the following steps:

1) defining the purpose and identifying the tasks of the information system;
2) formulation of requirements for the information system:
   - identification of the required functionality of the system and the level of its adaptability to constantly changing operating conditions;
   - determination of the required system capacity and system response time to a request;
   - determination of the required level of security;
   - identification of proposals for ease of operation and maintenance of the system;
3) design of the information system:
   - designing the architecture of the information system;
   - design of modules (blocks) of the information system;
   - determination of the network topology, hardware configuration, architecture used (file-server or client-server), parallel and distributed data processing, etc. (if necessary);
   - design of data objects to be implemented in the database;
   - designing screen forms and reports that will ensure the execution of data queries;
4) implementation of the information system;
5) testing of the information system:
   - standalone testing of modules (blocks);
   - integration and system testing of the information system as a whole;
   - acceptance testing;
6) commissioning of the information system;
7) operation and maintenance of the information system.

Let's design an information system for monitoring infectious patients using the proposed method. Let's start creating an information system by defining the goal, which can be generally defined as solving a number of interrelated tasks, including ensuring the launch of the system and its operation for a certain period of time. Thus, the *purpose* of the information system for monitoring infectious patients is to prevent the spread of epidemics and pandemics by tracking patient contacts and reducing the number of infections. The *tasks* of the information system for monitoring infectious patients are to track the self-isolation of infectious patients and their contacts, identify the most "infected" buildings, districts, cities, etc. based on intelligent analysis of data on infectious patients and their contacts.

Let's formulate generalized high-level requirements for an information system for monitoring infectious patients. Taking into account the identified tasks of the information system, we identify the necessary functionality of the system: geolocation of infectious patients, geolocation of contact persons of infectious patients, tracking of self-isolation of infectious patients, tracking of self-isolation of contact persons of infectious patients, issuance of urgent notifications about violations of self-isolation by infectious patients or their contact persons, intelligent analysis of data on infectious patients and their contacts, identification of the most "infected" buildings, districts, cities, etc. The

required system bandwidth is at least 100 Mbps; the system response time to a request is no more than 3 seconds. The required security level is high; as personal data will be processed. The system should have a simple, intuitive, user-friendly interface and be accessible to people of all ages. The system should be mobile-oriented (in the form of a mobile application).

Let's design an information system for monitoring infectious patients. The architecture of the information system for monitoring infectious patients is shown in Fig. 1.

The infectious patient is registered in the system/application (Module for registering an infectious patient in the system/application) and provides information about his/her contact persons (Module for collecting information about contact persons of an infectious patient). The provided data is recorded in the system's Database. During registration, the patient must provide access to the geolocation of his/her mobile device.

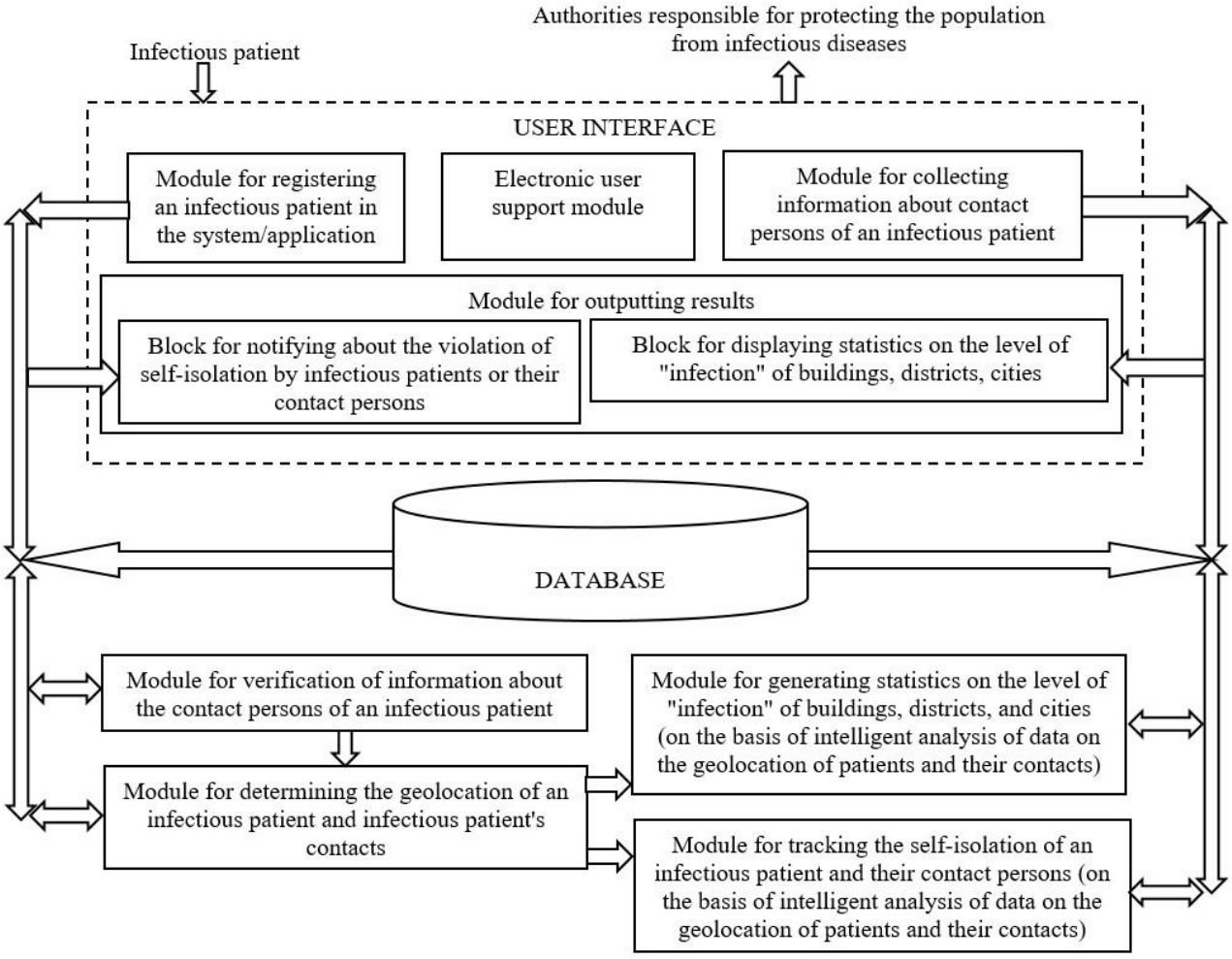


**Fig. 1. Architecture of information system for monitoring infectious patients**

The Module for verification of information about the contact persons of an infectious patient analyzes photos and videos from the last 3-5 days on a mobile device and in cloud environments to search for and recognize persons with whom the patient has had contact in the last 3-5 days, and also checks whether these persons are listed by the patient among the contact persons (this action is possible only if the patient has given permission to access his/her phone data - photos, videos, etc.)

The authorities responsible for protecting the public from infectious diseases contact the contact persons of the infectious patient and request them to register in the system/application. The system/application also tries to identify contact persons by contacts in the patient's mobile device (if the patient has provided such access) and send them a message that they are contact persons of the infectious patient and must register in the system/application.

The Module for determining the geolocation of an infectious patient and infectious patient's contacts records the geolocation of an infectious patient and his/her contacts and transfers them to the database, as well as to the Module for tracking the self-isolation of an infectious patient and his/her contacts and the Module for generating statistics on the level of "infection" of buildings, districts, and cities. Both of these modules work on the basis of intelligent analysis of data on the geolocation of patients and their contacts.

The Database of the information system stores registration data of infectious patients and information about their contact persons, geolocation of each infectious patient and their contact persons; in addition, the Database stores

statistics on the level of "infection" of buildings, districts, and cities, which is generated by the Data mining modules.

If the Module for tracking the self-isolation of an infectious patient and their contact persons has established that self-isolation has been violated, an appropriate urgent notification is displayed by the Block for notifying the authorities responsible for protecting the population from infectious diseases of violation of self-isolation by infectious patients or their contact persons. The Block for displaying statistics on the level of "infection" of buildings, districts, cities provides the authorities responsible for protecting the population from infectious diseases with relevant statistics.

The designed mobile-oriented information system for monitoring infectious patients can be used to prevent the spread of the pandemic by tracking contacts and reducing the number of infections.

The design of screen forms, reports, implementation, testing and commissioning of the information system for monitoring infectious patients will be carried out by the authors in the course of their further research.

## Conclusions

In the context of the COVID-19 pandemic, infectious disease information systems are widely used and promoted to prevent the spread of the pandemic (mainly in the form of mobile applications). Many countries have offered their apps to improve contact tracing and thus reduce the number of infections. However, the level of adoption of such applications has been and remains relatively low, which, obviously, given their massive use and effectiveness, has been largely influenced by issues related to privacy and anonymity, as well as the perception of potential users of the price-benefit ratio.

Thus, the task of creating information systems for monitoring infectious patients is still relevant today. Therefore, our study is devoted to the development of a method and an information system for monitoring infectious patients.

The article develops a method for creating an information system for monitoring infectious patients, which, unlike the known ones, is based on intelligent analysis of data on the geolocation of patients and contact persons, and provides the ability to design an information system for monitoring infectious patients.

The purpose of the infectious disease monitoring information system is to prevent the spread of epidemics and pandemics by tracking patient contacts and reducing the number of infections. The tasks of the information system for monitoring infectious patients are to track the self-isolation of infectious patients and their contacts, identify the most "infected" buildings, districts, cities, etc. based on intelligent analysis of data on infectious patients and their contacts.

The designed mobile-oriented information system for monitoring infectious patients can be used to prevent the spread of the pandemic by tracking contacts and reducing the number of infections.

The design of screen forms, reports, implementation, testing and commissioning of the information system for monitoring infectious patients will be carried out by the authors in the course of their further research.

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