

ABSTRACT
of the dissertation for the degree of Doctor of Philosophy (PhD)
specialty 6D070300 – «Information Systems (by industry)»

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**DEVELOPMENT OF INFORMATION TECHNOLOGY TO SUPPORT
DECISION-MAKING IN THE DIAGNOSIS OF BLOOD DISEASES**

The relevance of the work. Currently, the greatest attention is paid to the problem of development and application of information medical systems, their integration in the direction of building a single information space. Without diminishing the importance of these works, it seems necessary to pay attention to decision support systems, which are the direct "assistants" of doctors in the treatment and diagnostic process and should find their place in integrated systems. At the same time, it is worth remembering that it was with mathematical modeling of physiological processes and diagnostic computing systems that medical cybernetics began, and even then they had demonstrated their effectiveness and expediency in practical healthcare. One of the most important strategic directions of the development of the healthcare system is the organization of a single information space and its technological infrastructure.

To date, Kazakhstan's healthcare is moving towards automation of medical information processing and document management. This implies an increase in processing speed, thereby improving the quality of patient care, facilitating the work of medical and medical personnel.

In order to implement e-health in Kazakhstan, it is planned to develop and implement standards that make it possible to implement a service-oriented architecture. It, in turn, will ensure full interoperability between the information systems involved in supporting health processes. That is, this architecture allows the system to interact and function with other products or systems without any restrictions on access and implementation.

Today, the country is actively implementing an information technology platform, the so-called Unified Health Information System (UISZ), the main purpose of which is to create an information structure of healthcare of the Republic of Kazakhstan, corresponding to the level of economic, social, technical, technological development of society and ensuring the rational use of health resources with better provision of medical services to the population.

The creation of the UHIS involves the fulfillment of a number of tasks based on the development and implementation of common standards for the exchange of medical data, the use of a unified system for identifying accounting objects and subjects of information interaction in healthcare; as well as centralized management and open access to a database of common classifiers, reference books and standards, including a database of medical care standards, patient management protocols, state registers of medicines and medical devices.

The dissertation is dedicated to solving the urgent task of improving the e-health system, which is one of the areas of the state program «Digital

Kazakhstan». Since the health of the nation is one of the priority areas of the state policy of the Republic of Kazakhstan, at the moment it is very important to develop e-health, to introduce information and communication technologies in the healthcare system, which can bring the quality of medical services to a new level, which determines the relevance of the study.

The object of study is a system of indicators of clinical and hematological syndromes.

The subject of the study is information technology for decision support in the diagnosis of clinical and hematological syndromes.

The purpose of the work is to develop an information technology for support decision-making in the diagnosing of blood diseases, which can improve the efficiency of business processes for monitoring clinical and hematological syndromes.

The objectives of the study. To achieve the purpose it is necessary to solve the following tasks:

- to study the existing systems of decision support in medicine;
- to conduct an analytical review of existing methods and models for supporting medical decision-making and practical IT solutions for the diagnosis of clinical and hematological syndromes;
- to develop a conceptual model of information technology to support decision-making in diagnosing blood diseases;
- to develop a computational IT infrastructure for the technology for diagnosing blood diseases, combining intelligent methods of processing indicators of clinical and hematological syndromes;
- to develop an architectural design of the software complex for decision support in the diagnosis of blood diseases;
- to describe the results of implementation of fuzzy inference model and the computational algorithm of morphological classification of clinical and hematological syndromes;
- to analyze the effectiveness of the proposed information technology in the diagnosis of blood diseases.

The scientific novelty of the dissertation research is that for the first time to improve the efficiency of the processes of diagnosing blood diseases, a model of the IT infrastructure of clinical and hematological syndromes, integrating information, computing and communication infrastructure, is proposed.

The dissertation proposed an information technology for decision support in diagnosing blood diseases, based on an IT infrastructure for diagnosing clinical and hematological syndromes, integrating a computational algorithm for morphological classification, a method for evaluating the information content of diagnostic indicators and a hybrid algorithm for Stacking ensembles of intelligent processing of the clinical and hematological syndromes indicators. The dissertation developed the architecture and implementation of the modules of the software complex for decision support in the diagnosis of blood diseases.

Scientific provisions and results submitted for defense:

- the decision support in the diagnosis of blood diseases;

- the model of integrated IT infrastructure of clinical and hematological syndromes, combining information, computing and communication infrastructure;
- the architecture of the software complex for the diagnosis of clinical and hematological syndromes, based on the integration of three-level, object-oriented and component architectural patterns.

The practical value of the dissertation research results is the applicability of the conceptual model of information technology for decision support and the IT infrastructure for diagnosing blood diseases, proposed in the dissertation, as well as the architectural design of the system, for solving the tasks of information and analytical support for managerial decision-making while accompanying business processes for monitoring clinical hematological syndromes.

Research Methods. The work uses the apparatus of the theory of systems management, the theory of statistical analysis, the theory of artificial intelligence, the theory of economic and mathematical methods and models, the theory of information systems design.

Implementation of the work results. The main scientific and practical results of the dissertation, presented in the form of a software module for diagnosing clinical and hematological syndromes, were adopted for implementation on the basis of SUC on REM "City rheumatological center of Almaty" and the software module "Assessment of the diagnostic indicators' informativeness of the clinical and hematological syndromes" implemented in JSC "Kazakh Institute of Oncology and radiology" Almaty.

A certificate of state registration of rights to the copyright object was received under the name "Software module for diagnosing of clinical and hematological syndromes (computer program)" No. 4737 dated August 1, 2019.

Approbation of the work. The main results of the dissertation were reported and discussed at the following international conferences: «Computer science and Applied Mathematics», devoted to the 25th anniversary of Independence of the Republic of Kazakhstan and the 25th anniversary of the Institute of Information and Computing Technologies (Almaty, 2016); II International scientific conference «Computer science and Applied Mathematics» (Almaty, 2017); 4th International Conference on Computer and Technology Applications (Istanbul, 2018); 4th International Conference on Engineering and MIS2018 (Istanbul, 2018); «Communications in Computer and Information Science» (Ust-Kamenogorsk, 2018); «Application of Information and Communication Technologies - AICT2018» (Almaty, 2018); 5th International Conference on Engineering and MIS 2019 (Astana, 2019); 12th IEEE International Conference «Application of Information and Communication Technologies - AICT2019 (Baku, 2019).

Publications. On the topic of the dissertation, 26 scientific papers were published, including 1 article in the journal with a CiteScore percentile in the Scopus database is 33, another 7 articles were published in publications indexed in the Scopus and Web of Science databases, 8 works in publications recommended by the Committee for Monitoring in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 16 works in collections of international conferences, including 2 articles in publications abroad.

Publications “Decision support system for diagnosing anemia” and “Informational and analytical system to diagnose anemia”, published in Scopus (and Web of Science), were cited 4 and 3 times, respectively. The Hirsch index of the author for the Scopus database is 2, for the Web of Science - 1.

Structure of dissertation. The dissertation consists of an introduction, 4 chapters, conclusion, a list of literature containing 113 titles, applications. The work is presented in 126 pages of typewritten text, contains 57 figures, 26 tables and 10 annexes.

The first section of the dissertation presents the results of the analysis of the current situation, prerequisites and main directions of e-health development in Kazakhstan. The relevance of designing decision support systems for diagnosing various diseases that increase the efficiency of medical specialists through the introduction of various methods of data analysis and medical data is substantiated. A review of existing methods and models for supporting medical decision-making was conducted, as well as architectural models and models for managing health information systems were studied.

The second section of the dissertation describes the development of a conceptual model of information technology for decision support in the diagnosis of blood diseases, based on the module of RAM, knowledge base, user interface module, logical inference procedures, as well as the module of filling and checking the knowledge base. The article describes the development of an it infrastructure for diagnosing clinical and hematological syndromes, which includes a computational algorithm for morphological classification, a method for assessing the information content of diagnostic indicators and a hybrid algorithm for Stacking-ensemble of methods for intellectual processing of clinical and hematological syndromes.

The third section of the dissertation presents the development of the architecture of the software complex for diagnosing clinical and hematological syndromes, based on the integration of three-level, object-oriented and component architectural templates. The description and justification of the software tools of the decision support system are presented. A model of the classes of the system was developed and described, and a database for the diagnosis of clinical and hematological syndromes was designed to support decision-making. The main requirements that should be presented to the implemented system were identified. The analysis is carried out and the choice of tools for the development of a diagnostic system for clinical and hematological syndromes is made.

The fourth section of the dissertation describes the results of an experimental study of the proposed information technology for decision support, as well as the evaluation of the effectiveness of the proposed information technology in the diagnosis of blood diseases. A software implementation of a computational algorithm for diagnosing clinical and hematological syndromes based on an anemia diagnosis algorithm and allowing classifying anemia according to morphological characteristics and quantifying the severity of the pathological process is presented.