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CONCEPTS OF CREATING AN INTELLIGENT MEDICAL DIAGNOSTIC SYSTEM TO ASSIST IN THE WORK AND TRAINING OF DOCTORS BASED ON ARTIFICIAL INTELLIGENCE

Abstract. *The article is devoted to the development of intelligent medical diagnostic systems using information systems and technologies. The article provides an overview of the current state and development of information systems, technologies and artificial intelligence in the medical field, analyzes existing intelligent diagnostic systems in medicine and cardiology in particular, and proves the need to create intelligent systems to help primary care physicians and cardiologists. The purpose of the publication was to investigate the current state of intelligent medical diagnostic systems, analyze the shortcomings of such systems, determine the feasibility of creating a new diagnostic system, and formulate principles and criteria for its operation. The scientific novelty of the article is a new approach for diagnosing and treating patients, as well as training medical professionals using an intelligent medical system based on artificial intelligence. Leveraging advanced AI algorithms, the system analyzes vast datasets encompassing patient records, medical literature, and real-time clinical data to provide accurate and timely diagnostic insights. The intelligent medical diagnostic system operates as a supportive tool, aiding doctors in the diagnostic process by offering refined suggestions, identifying potential anomalies, and recommending personalized treatment plans. By harnessing machine learning and deep learning techniques, the system continuously adapts and evolves, learning from each diagnostic scenario and refining its predictive accuracy over time. Through interactive simulations and case-based learning modules, aspiring and practicing doctors can engage in immersive, realistic scenarios, honing their diagnostic skills and expanding their knowledge base. The disadvantages of this article include only a theoretical approach to the formation of concepts and tasks for an intelligent medical system, and a review of existing systems.*

Key words: *diagnostics, intelligent information system, training, forecasting, artificial intelligence.*

КОНЦЕПЦІЇ СТВОРЕННЯ ІНТЕЛЕКТУАЛЬНОЇ МЕДИЧНОЇ СИСТЕМИ ДІАГНОСТИКИ ДЛЯ ДОПОМОГИ В РОБОТІ ТА НАВЧАННІ ЛІКАРІВ НА ОСНОВІ ШТУЧНОГО ІНТЕЛЕКТУ

Анотація. *Стаття присвячена розвитку інтелектуальних медичних систем діагностики з використанням інформаційних систем та технологій. У статті представлено огляд сучасного стану і розвитку інформаційних систем, технологій та штучного інтелекту в медичній галузі, проаналізовано існуючи інтелектуальні системи діагностики в медицині та кардіології зокрема, доведено необхідність створення інтелектуальних систем для допомоги лікарям первинної ланки та кардіологам. Метою публікації було дослідити сучасний стан інтелектуальних медичних систем діагностики, проаналізувати недоліки таких систем, визначити доцільність створення нової системи діагностики та сформулювати принципи та критерії для її роботи. Науковою новизною статті є новий підхід для діагностики та лікування пацієнтів, а також навчання медичних працівників за допомогою інтелектуальної медичної системи на основі штучного інтелекту. Використовуючи передові алгоритми штучного інтелекту, система аналізує великі масиви даних, що охоплюють записи пацієнтів, медичну літературу і клінічні дані в режимі реального часу, щоб надати точну і своєчасну діагностичну інформацію. Інтелектуальна медична діагностична система працює як допоміжний інструмент, допомагаючи лікарям*

у процесі діагностики, пропонуючи уточнені пропозиції, визначаючи потенційні аномалії та рекомендуючи персоналізовані плани лікування. Використовуючи методи машинного та глибинного навчання, система постійно адаптується та розвивається, навчаючись на кожному діагностичному сценарії та вдосконалюючи свою точність прогнозування з часом. Завдяки інтерактивним симуляціям і навчальним модулям, заснованим на конкретних випадках, лікарі-початківці та практикуючі лікарі можуть брати участь у захоплюючих, реалістичних сценаріях, відточуючи свої діагностичні навички та розширюючи свою базу знань. До недоліків даної статті можна віднести лише теоретичний підхід до формування концепцій та задач до інтелектуальної медичної системи, огляд вже існуючих систем.

Ключові слова: *діагностика, інтелектуальна інформаційна система, навчання, прогнозування, штучний інтелект.*

Introduction. In 2019, Ukraine conducted the first nationwide survey to study the prevalence of noncommunicable disease (NCD) risk factors – STEPS [1].

The STEPS study reflects the World Health Organization's (WHO) STEPwise approach to noncommunicable disease risk factor surveillance and is a simple, standardized method for collecting, analyzing and disseminating data in WHO member countries.

The STEPS tool covers three different levels of risk factor assessment – three steps: questionnaires, physical measurements, and biochemical analyses. Each level is divided into basic, advanced and additional modules that can be used in the study depending on the conditions and needs of different countries.

The research results can be used not only to study trends within a country, but also for comparisons between countries. In particular, they contain socio-demographic indicators, data on alcohol and tobacco consumption, nutrition, physical activity, blood pressure, glucose, cholesterol, information on the presence of circulatory system diseases, physical examination data, and biochemical indicators.

More than 130 countries around the world have participated in STEPS at least once. In some countries, this study has been conducted several times, while in Ukraine it was organized for the first time. The study was conducted in 2019, and in 2021, WHO presented the results to the public.

In Ukraine, cardiovascular disease is the leading cause of death. By this indicator, our country remains one of the world leaders (Figure 1) [2].

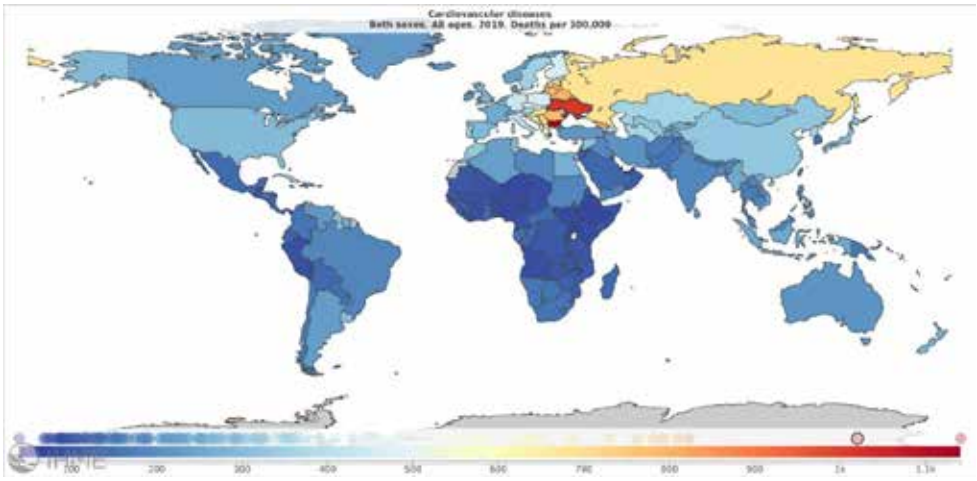

Fig. 1. Statistics from IHME (Institute for Health Metrics and Evaluation founded by Bill and Melinda Gates). Global mortality rates from cardiovascular diseases in 2019

According to a ranking based on the number of deaths in Ukraine, the most common causes are:

1. Cardiovascular diseases (64.3%).
2. Neoplasms (14.1%).
3. Diseases of the digestive system (4.3%).
4. Neurological disorders (3.1%).
5. Self-harm and interpersonal violence (2.7%).

It was also possible to identify the most common causes of death from cardiovascular diseases by gender among all age groups (Table 1).

Table 1

Causes of death of Ukrainians from cardiovascular diseases

№	Male	Female
1	Coronary heart disease	Coronary heart disease
2	Cerebrovascular diseases	Cerebrovascular diseases
3	Cardiomyopathy and myocarditis	Cardiomyopathy and myocarditis
4	Diseases of peripheral vessels	Atrial fibrillation
5	Aortic aneurysm	Diseases of peripheral vessels
6	Atrial fibrillation	Other cardiovascular diseases
7	Other cardiovascular diseases	Hypertensive heart disease
8	Hypertensive heart disease	Rheumatic heart disease
9	Rheumatic heart disease	Aortic aneurysm
10	Endocarditis	Non-neuromuscular valve disorders

From the above data, we can conclude that cardiovascular diseases require more attention, especially in Ukraine. The average time for an outpatient visit to a doctor is 15-20 minutes, during which it is impossible to fully diagnose a patient's problem and prescribe treatment. The patient has to undergo a large number of tests and repeatedly come to the doctor's office. There are also often difficult cases when the doctor is unsure of the diagnosis and needs to prescribe additional tests or an outside expert opinion. These problems can be solved by optimizing the work of healthcare professionals with an AI-based intelligent cardiovascular disease diagnostic system that would predict diagnosis and treatment based on the available medical history to verify the doctor's preliminary diagnosis, work in conditions of incomplete information, suggest additional necessary tests (if necessary), and help with the determination of the treatment regimen.

Problem statement. Resistant arterial hypertension (RAH) is defined as hypertension in which blood pressure (BP) remains above the target level despite the simultaneous use of 3 antihypertensive drugs of different classes [3]. Ideally, one of the 3 drugs should be a diuretic and all drugs should be prescribed in optimal doses. Despite the relative arbitrariness of the requirements for the number of prescribed drugs, resistant hypertension is defined in order to identify patients who are at higher risk or who have treatable causes of hypertension and/or patients who may benefit from additional special diagnostic and therapeutic measures due to persistently high blood pressure. As defined, resistant hypertension includes patients whose blood pressure is controlled with more than 3 medications. That is, patients whose blood pressure is controlled but requires 4 or more medications should be considered resistant to treatment (Figure 2).

The study focused on the problem of predicting the probability of true resistant hypertension based on the analysis of general clinical data for primary care physicians (family doctors, general practitioners). This intelligent system is designed for both primary care physicians and subspecialists – cardiologists, because patients always see a primary care physician first, and then a subspecialist. The task consists of two stages: 1) to create an intelligent system based on artificial intelligence, which, based on the available tests and data from the primary care physician, could determine whether the patient has true or false resistance to treatment of hypertension. 2) If the patient does have true resistance, which fourth-line drug would be appropriate for him or her to overcome hypertension.

The analysis is based on two groups of patients: controlled hypertension (CH) and resistant hypertension (RH). To determine the patient group, the physician must have the following patient data:

- office blood pressure (BP) level;
- heart rate;
- duration of arterial hypertension (AH);
- body mass index (BMI);
- waist circumference (WC);
- history of stroke;
- coronary heart disease (CHD), myocardial infarction;
- atrial fibrillation (AF);
- diabetes mellitus (DM);
- ECHO cardiography parameters (Tcp, Tmrp, LVMI, LV);
- blood test results: potassium, sodium, creatinine, total cholesterol, LDL cholesterol, TG, glucose, CRP, uric acid (UA);
- glomerular filtration rate (GFR);
- albuminuria (BUN).

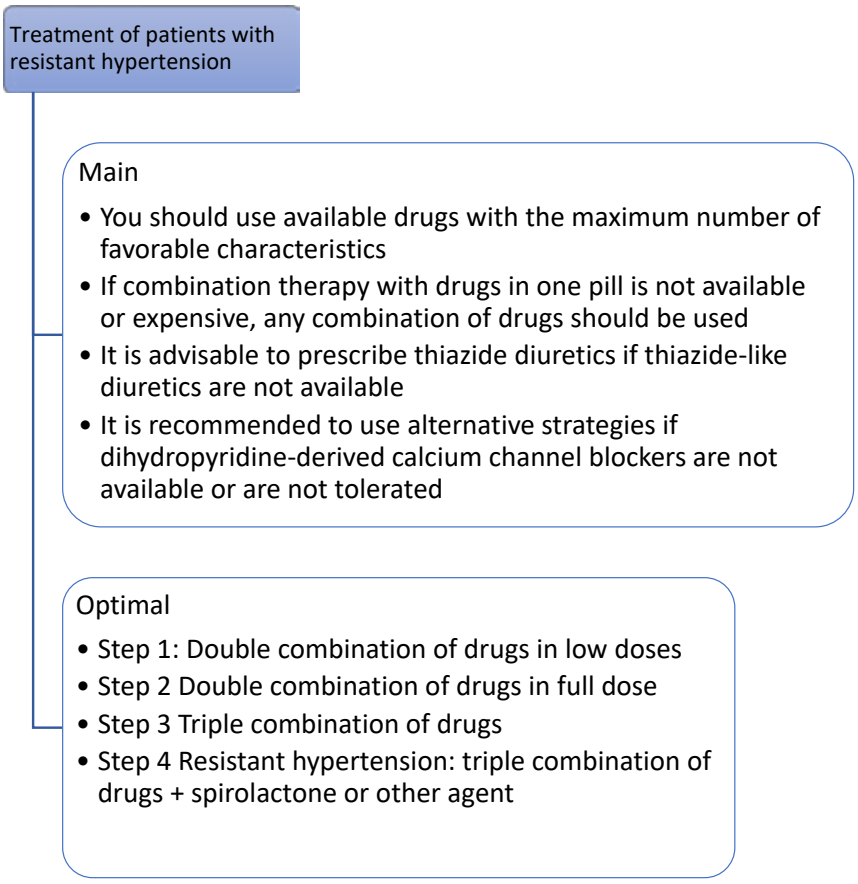

Fig. 2. Pharmacological strategy for the treatment of patients with hypertension in accordance with the standards

These parameters can be used to identify truly resistant patients. If the patient does not have true resistance, it means that he or she is pseudo-resistant, which may be due to: incorrect BP measurement technique, low adherence to treatment, and "white coat" hypertension [4]. If therapy is followed correctly, a pseudoresistant patient will overcome hypertension. After that, the intelligent system should determine the sensitivity to the fourth antihypertensive drug in patients with true RAH based on all available indicators.

Intelligent information system. An intelligent information system (IIS) is a type of automated information system; a set of software, linguistic and logical-mathematical tools for the implementation of the main task: to support human activity and search for information in the mode of extended dialogue in natural language [5].

The characteristic features of IIS are:

1) developed communication skills;

2) the ability to solve complex and poorly formalized problems;

3) ability to develop and self-learn.

Intelligent information systems can be divided into 3 classes (Table 2):

Table 2

Classification of intelligent information systems

Class I: systems with an intelligent interface (communication abilities)	Class II: expert systems (solving complex problems)	Class III: systems capable of self-learning
1. Intelligent databases	1. Systems that classify	1. Inductive systems
2. Natural language interface	2. Systems that redefine	2. Neural networks
3. Hypertext systems	3. Systems that transform	3. Precedent-based systems
4. Contexts and systems	4. Multi-agent systems	4. Information repositories
5. Cognitive graphics		

Intelligent diagnostic systems in cardiology. Intelligent systems based on artificial intelligence are constantly becoming more widespread and in demand in medicine, especially in certain areas such as ophthalmology, cardiology, oncology, orthopedics, and dentistry [6]. It can be concluded that the use of intelligent diagnostic systems in medicine is widely used and is in demand and expedient. Let's consider the feasibility of using intelligent diagnostic systems in cardiology, since cardiovascular mortality is the highest in Ukraine.

As of today, there are many works and created intelligent diagnostic systems dedicated to cardiology. Among them:

1) Intelligent decision support system for radionuclide diagnostics in cardiology [7];
2) Ischemic heart disease [8];
3) Valvular heart disease [9];
4) Atrial fibrillation [10];
5) Heart failure [11];
6) Cardiomyopathy [12];
7) Congenital heart disease [13];

An analysis of publications [7-13] confirms that the creation of intelligent systems based on artificial intelligence improves the diagnosis and treatment of both cardiac and general diseases. Since the problem of identifying a patient with hypertension treatment resistance is extremely urgent and poorly diagnosed by doctors, it would be advisable to use information systems and technologies to solve this problem.

Consider the problem of intellectual classification of a set of patient's signs in order to prescribe the optimal method (protocol) of hypertension treatment

Algorithm for improving the diagnosis and treatment of true/false resistance of hypertension:

1) Examination of a patient with controlled/resistant hypertension by a primary care physician, examination, and initial tests. After receiving the tests, the doctor uses an intelligent system to classify the patient (enters all available data).

2) Classification task. Determine whether the patient has true drug resistance (if the resistance is false, the patient needs to lose weight, modify lifestyle, strictly adhere to medication, and if these conditions are met, hypertension will be controlled and blood pressure will be within normal limits).

Diagnosed: if the patient's blood pressure is above 160 mmHg, lifestyle modifications have been made, weight is normal, and the patient is taking 3 antihypertensive drugs, the primary care physician assumes that the patient has true resistance to antihypertensive drugs and refers the patient to a specialized cardiologist.

Proposal: The primary care physician enters all available patient data (age, gender, height, weight, race), test results, and patient lifestyle questionnaire data into the app; the neural network classifies the patient into one of two groups based on the available data.

3) If resistance to three drugs is true, the cardiologist must select a fourth drug to stabilize the patient's blood pressure.

Diagnosed: the doctor tries to determine the optimal combination for the patient by selecting different drugs (time-consuming, costly, the patient will have high blood pressure and discomfort for a long time due to the search for a combination that suits him).

Proposal: the app will calculate which fourth drug will be suitable for this particular patient based on additional tests and trained on a large sample of patients.

Conclusion. The most common cause of death in Ukraine is cardiovascular disease. Stabilizing blood pressure can significantly reduce mortality and improve the quality of life of patients. To determine the true resistance of hypertension, speed up the diagnostic process, understand the feasibility of prescribing additional tests, and select the fourth line of therapy for patients with resistant hypertension, it would be advisable to use an ANN to solve the decision-making problem. It is proposed to create an artificial neural network (multilayer perceptron), where the inputs will be the basic data for determining the group of patients with true hypertension, and the output will be one, because it is a binary classification task. The following publications will discuss the results of the described ANN. The intelligent medical diagnostic system represents a pioneering advancement in the healthcare landscape, revolutionizing the diagnostic process and elevating the standard of medical education. As AI continues to evolve, its synergistic integration with human expertise holds the promise of a more efficient, accurate, and personalized healthcare experience.

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