

# Information communication texnolgy for monitoring of a prenosological state of the population health

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## Research

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# Abstract

**Background:** The article describes the development of an uninterrupted functioning technology for remote automated monitoring of the prenosological level of individual health, which allows optimizing the medical non-invasive mass examination of the population.

**Methods:** In order to provide their functioning by using information and communication technologies, mobile communications, automated remote exchange methods, accumulation, storage of information, as well as involving medical knowledge, mathematical models and algorithms for their intellectual analysis, the opportunities have been created for the development and implementation of preventive measures that are effective mechanisms to ensure a healthy lifestyle.

**Results:** According to the stated goal, a comprehensive monitoring of the physical, functional and clinical-somatic status of population health indicators is carried out. It provides the implementation of the functions of a comprehensive prenosological examination of citizens and the results of the surveys assess the risk of developing certain diseases; assisting in the implementation of measures to form a healthy lifestyle and reduce the spread of risk factors for noncommunicable diseases among the attached population; dynamic monitoring of the contingent of individuals at increased risk of developing the disease. The practical use of this technology helps to conduct mass prenosological examinations of the population and improve the quality of targeted, personalized prevention of risk factors and improve their health.

## Background

Today, modern medicine has countless opportunities and technologies for the diagnosis and treatment of the most complex diseases, yet even with all this great advancement it still mainly deals with already diseased people who need medical attention. This means, that sadly instead of carrying out prognosis and prevention of possible diseases, the current goals were concentrated on fighting the already unhealthy individuals. Thus, one of the crucial assignment of health care, maintaining public health, cannot be fulfilled if it is mainly focused only on the treatment of diseases. It puts the prognostic aspect at the heart of the health problem: the necessity to predict an individual trajectory from fully healthy to ill. The medicine of the future should focus on maintaining the health of healthy people rather than treatment. Currently, the term "health" is often interpreted as an absence of any disorders. The World Health Organization has defined health as a complex state of physical, mental and social well-being. The Health Science is a complex and multi-layered study of, not only, the physical health, but also the environment, we are living in, which is saturated with both stressful and joyful situations that affects the individuals. The negative effects this may lead to is also so-called "the third state". The concept of the "third state" in assessing human health is actually based on the laws of ancient medicine, laid out more than a thousand years ago by the famous physician and philosopher Abu Ali Ibn Sina – Avicenna, which highlights six human health conditions: a healthy body to the perfection; a healthy body, but not to the perfection; the body is not healthy, but not sick at the same time; a body that easily perceives health; a

body is sick, but not to the limit; the body is sick to the limit [1]. Out of all these conditions, only the last two relate to the illness. Between these two extreme levels of health (according to Avicenna), we distinguish four transition states with varying degrees of tension in regulatory systems: normal, moderate, pronounced and over-voltage [2]. Consequently, the transition from healthy organism to disease occurs through overstrain and the breakdown of adaptation mechanisms. And the sooner it will be possible to foresee such an outcome, the more likely it is to maintain the well-being of the population. Health is considered as a process of continuous adaptation of the body to environmental conditions, and a measure of health, is the adaptive capabilities of the body. Hence between health and illness, occurs a whole series of marked transitional conditions, called prenosological conditions.

These points, together with the unresolved problems of rational organization and management of the lifestyle of the majority of the population, are the basis for the massive occurrence of prenosological disorders and their inevitable transformation into various forms of pathology, as well as part of the global problem with maintaining health. For instance, the results of mass preventive examinations showed that 50% to 80% of the population is at different stages of prenosological conditions [3]. Thus, most people do not need medical diagnosis (diagnosis of diseases), but prenosological diagnosis instead. The concept of adaptive capabilities of an organism includes two aspects: diagnostic and prognostic. The first represents the current state of the body, the stock of its functional reserves and the corresponding voltage of regulatory systems. The second characterizes the potential ability of the body to perform a particular activity. Adaptation reserves, in general, represent the ability to resist the effects of various types of loads, adapt to these loads, minimizing their impact on the body, while ensuring the proper level of effective human activity of cells, tissues, organs and the whole organism, while providing the proper level of effective human activity. The body's adaptive reserves are essentially a criterion of physical health.

We can conditionally differentiate the following stages of the body [2, 3]:

- State of satisfactory adaptation;
- State of voltage adaptation mechanisms (unstable or incomplete adaptation);
- State of unsatisfactory adaptation, overstrain of adaptation mechanisms;
- Failure of adaptation state (depletion of adaptation mechanisms).

Recognition of these functional states, reflect the outcomes of adaptive behavior, it is called the prenosological diagnostics (PD), as this determines the conditions preceding the development of nosological forms of diseases. This is exactly what the prognostic aspect of prenosological diagnostics consist of, which recognizes the current functional state of the organism.

## **The Purpose And Objectives Of The Research**

Today, disease prevention is the most important public health priority, aimed to create motivation for a healthy lifestyle among the population, fortification of the physical and mental health and maintaining

the well-being of the population.

This assignment is, undoubtedly, the most important in health care reform, considering that it has the most significant economic role associated with maintaining people's health, improving labor potential, as well as a significant reduction in the population's need for medical care. The significance of prevention and healthy lifestyle was postulated in the Government Decree of the Republic of Uzbekistan No. 718 of September 13, 2017. Which included implementation of measures for the prevention of diseases, promotion of a healthy lifestyle and the formation of a sanitary-hygienic culture among the population was defined as the main direction of preventive medicine. The goal was to ensure the early detection of diseases by organizing high-quality preventive examinations which ensure the full implementation of preventive measures and to introduce their systematic monitoring as a priority task of the country's health care system. In connection with the foregoing, the urgent task of the health care system of the Republic at the present stage, along with increasing the efficiency of nosological diagnostic and treatment processes, i.e. the treatment of already sick people. Is the organization of mass prenosological examinations to assess the level of the functional health state of the population and the introduction of their monitoring system, early identification of risk factors (RF), and if necessary, the implementation of preventive measures to correct them, ensuring the preservation of the health. Taking into account the volume of information received and processed, as well as the unorganized nature of prenosological examinations of the population, for the implementation of the above-mentioned solutions into practice, it is necessary to develop special remote, mobile information and analytical communication technologies that automate the collection of primary personalized information, its storage, monitoring and intellectual data analysis, identification of risk factors and prediction of health status population. It should be noted that the goal of health monitoring, based on data on the individual characteristics and capabilities of the body, is to ensure the preservation of health in the process of its individual development. In fact, this task is related to ensuring the health of population and first of all, it requires PD of an individual level of health and early identification of risk factors, assessment of the level of morphological and functional indicators of the body, identification of negative trends, and if necessary, without waiting for the manifestation of the disease, timely implementation of effective targeted and individual preventive measures. Prenosological changes in the body parameters are the earliest and most common. They reflect the cumulative effect on the human health various adverse factors and therefore they should be monitored first. The problem of assessing the prenosological level of health is primarily associated with the development of effective and highly informative methods for their diagnosis [2-4]. Conventional diagnostic technologies of clinical medicine determine the state of health in terms of the existence or absence of any pathological changes. The prenosological state does not go beyond the limits of the clinical norm. At the level of the laboratory and instrumental investigation, it does not show significant changes in the generally accepted norm, therefore it falls outside of the field of view of doctors. PD considers reducing the adaptive capacity of the body as a leading cause of the onset and development of diseases. Its primary task, is to obtain a scientifically based answers to the question of how far it is for a person possible adaptation and development of the disease. The next task to take is what are preventive measures necessary to improve adaptation and health. The most important mission of preventive medicine is the search for direct tools

for prenosological diagnosis and their disclosure as innovations in the provision of services in the social sphere, examination of practically healthy individuals in order to detect RF, latent and unrecognized cases of diseases. Thus, it allows early detection of developing diseases before the clinical symptoms are detected. Ultimately, it allows increasing the level of health of the population, which is one of the priority areas of modern medicine. In this aspect, the development and implementation of new approaches and methods that could improve the quality, reliability, mass character and targeting of prenosological diagnostics is especially relevant.

## Results

Through the technology developed by us, we can use algorithms and software for distance automated monitoring of the prenosological level of an individual health. This will allow us to optimize dispensary examinations of the population, ensure their necessary coverage, low-cost, operate continuously and when using modern algorithms for recognizing specified signs, it is intelligent. A condition needed for the implementation of the project is the assignment of the role of the correspondent, at least one in each family, which will oversee transmission and reception of personal electronic medical data to the population itself. At the same time, in order to minimize financial costs for the purchase of foreign medical gadgets, it is necessary to train the population to receive data on the morphological and functional indicators of the body using non-invasive and generally accessible methods and send them to the appropriate health center serving its territorial unit, using a personal mobile phone. The hardware and software provision of each such module requires the presence in each family of at least one unit of mobile communications with the necessary parameters and connected to the Internet. For all, such mobile communications will be equipped with the correct software and the interfaces for exchanging information with the server of our health center. This will make it possible to put into practice the principle - a mobile patient - a virtual doctor. By creating an individual monitoring of the prenosological level of health based on this principle, and organizing its modular functioning for a specific region of the population of a given geographical area with the involvement of prevention doctors responsible for this area of the family clinic, significant results can be achieved in preventing risk factors, and maintaining of the health of the population. As a module, we have taken the conventional eastern public structure - citizens' self-government - "mahalla", an association of citizens created in their place of residence and functioning in accordance with the special law of the Republic of Uzbekistan. The described modular principle and mechanism for distance monitoring of the prenosological level of individual health, as a pilot project, we are implementing among the student of the Ferghana branch of the Tashkent Medical Academy - as a structural unit. The architecture and diagram of the information and analytical remote technology developed by us is presented in Fig. 1. In the initial version of the technological project, using the effective non-invasive methods for assessing the level of health described in the literature [5-10], we envisage implementation, based on individual indicators of students, and medical knowledge bases (formed from literature data on quantitative and qualitative criteria for evaluating certain indicators of body health level), remote individual assessment: adaptive potential and functional reserves of the body. State of autonomic regulation of the cardiovascular system, a prediction of the possibility of developing

arterial hypertension, as well as a number of anthropometric and morphofunctional indices, allowing to evaluate the prenosological level of their somatic health.

The following assessment of physical status was obtained by the general method of somatometry with the calculation of evaluating indices: average values of the Kettle index (IR). An increased Kettle index is considered as one of the risk factors for arterial hypertension. Based on anthropometric data, the Piñe indices were calculated, according to which the somatotypes of the examined were determined.

The simplified algorithm of prenosological diagnosis describes well the functional states where a stable relationship between the main physiological parameters is preserved. According to the study of the functional status, the value of the indicators of physiological reserves of the respiratory system, of the Stange and Gencha samples was obtained. The data obtained reflect the power levels and the efficiency of aerobic energy production. To determine resistance to hypoxia, an index - the ratio of resting heart rate to inspiration apnea duration was calculated. One of the informative prenosological integral indicators reflecting the features of adaptive reactions of the body in a healthy population of people is the type of self-regulation of blood circulation (TSBC). Based on an integrated assessment of the cardiovascular system, analysis of the ratio of the cardiac and vascular components of central hemodynamics N.I. Arinchin et al. Established the existence of three types of TSBCs in healthy people: cardiac, vascular, and cardiovascular [9]. Determination of TSBC makes it possible to assess the level of tension in the regulation of the cardiovascular system. It is worth mentioning that the prospect of the transition of the prenosological state into the disease is determined by the adaptive capabilities of the body and, in particular, the regulation of physiological functions. Therefore, an important position in promising medical control systems should be taken by information technologies aimed at assessing the state of regulatory systems, since, as already mentioned, it is the over strain of regulatory mechanisms, as well as the associated decrease in functional reserves, that is one of the main risk factors for the development of diseases [6]. The cardiovascular system, as a sensitive indicator of adaptive reactions of the whole organism, is the first to respond to all fluctuations in environmental conditions, it is a regulator of the internal body environment, maintaining homeostasis of its organs and systems through their adequate blood supply. In this regard, as a criterion of the adaptive capabilities of the organism R. M. Baevsky, A. P. Bersenev proposed to determine the index of functional changes (IFCh) [2],  $IFCh = 0.011HR + 0.014SAP + 0.008DAP + 0.014A + 0.009BW - 0.009H - 0.27$ , for the calculation of which only data on the heart rate (HR) are required, diastolic and systolic arterial pressure (DAP, SAP), height (H), body weight (BW) and age (A) obtained by non-aggressive methods. Based on the obtained IFCh value, each individual, depending on the degree of adaptation, can be assigned to one of four groups (satisfactory adaptation, tension of adaptation mechanisms, unsatisfactory adaptation, failure of adaptation): the higher the conditional score of the IFCh, the higher the likelihood of pathological deviations. Pre-medical screening, based on the evaluation of IFCh, with all its simplicity, provides a systematic approach to assessing the functional state of the circulatory system as an indicator of the adaptive capabilities of the body as a whole. The level of functional reserves, which we monitored according to the Kournikova approach, is an independent prenosological indicator of health, adequately reflecting the state of the

body's adaptation systems to adverse environmental influences [7]. Moreover, it is the most sensitive and dynamic criterion that allows identifying priority risk factors.

We should point out that the protocol of examination depends on the purpose of the prenosological examinations and may vary depending on the tasks and the volume of the studies. The software for evaluating the results of analysis and forming conclusions is the most important and a crucial part of the technology of prenosological studies. The issues of constructing algorithms for recognition various classes of prenosological conditions are fundamental in solving the problems of automation of mass prenosological diagnostics associated with the examination of large populations. Here, the selection of the most informative indicators is necessary and their minimization with the development of optimal decision rules. The algorithm, as an exact instruction of execution order for a certain group of actions or operations, may lead to the solution of the task, but it should construct on scientifically based criteria. In this case, in terms of algorithms for prenosological diagnostics, we are referring to physiological criteria that we have accumulated in the knowledge base of the analytical unit of our system. At the same time, we have taken into account that various physiological indicators used in assessing the functional state have different information content and accordingly make an unequal contribution to obtaining the final result in the formulation of the prenosological diagnosis. Assessing the level of human health by individuals, even if informative, indicators do not give a holistic view. The integration of separate parameters is necessary in order to obtain a total quantitative indicator (index) of the health. This gave a reason to introduce the idea of a prenosological syndrome as an indicator of a complex of certain deviations of different indicators. To assess the integral level of health, we used the Apanasenko method, where a similar approach was implemented using 5 indicators of the body [15]. The listed factors, adequately characterizing the level of the prenosological state of the body, are calculated on the basis of data determined by non-invasive and comfortable methods, which are important for prenosological monitoring of the health of individuals. Algorithms for the analysis of recorded indicators, including morphofunctional development, functional reserves and the condition of leading organs and systems, using factor analysis, provide a clear relationship between morphofunctional development indicators and health status, and the determination of the individual's internal health structure. This function is performed by using the algorithm developed by us and the software for their automated computer implementation which allows us to assign each object of investigation to one of the following categories and from the corresponding population databases:

1-category: contingent with a high level of healthy individuals that do not require the implementation of any preventive measures - the contingent of the green folder base;

2-category: people with risk factors for health - the contingent of the base of the yellow folder;

3-category: people with one or more chronic diseases - the contingent of the red folder base.

We should point out that to identify each monitoring object in the database and in all information registers, they will be assigned a 15-digit single individual number by which you can set its address and status in the family, and, if necessary, convert it to information according to its passport data. Thus,

according to the goal, a comprehensive monitoring of the physical, functional and clinical-somatic status of population health indicators is carried out. It provides for the implementation of the functions of prenosological diagnosis, screening and control, namely:

Comprehensive prenosological examination of citizens, including anthropometric and other morphological, and functional indicators.

Screening, assessment of the level of somatic health, functional and adaptive reserves of the body, rapid assessment of cardiovascular, and autonomic system, assessment of complex indicators of the function of the respiratory system.

Based on the results of the surveys, an assessment can be conducted to assess the level of risk of onset of certain diseases.

## **Discussion**

Today, a number of systems and mobile applications have been developed for monitoring and tracking the health [11-13]. The issues of the need to create and implement remote monitoring of human health indicators as a means of improving the quality of medical care for patients and the main features of creating a specialized automated system for these purposes are considered in [14].

Information technologies [11] open up a new possibilities in early and individualized prenosological diagnostics, which are a useful tool for accurate and standardized assessment of the result of external adverse effects on human health and general physical condition, which are methods of early prenosological diagnosis. The paper [12] presents the conceptual foundations and architecture of the Internet system of personalized health care based on intensive data analysis, describes the structure of the health management space and the general architecture of the Internet system of personalized health care support. In this regard, the works of Tomsk State University, an information system for monitoring the adaptive abilities and functional reserves of a person, also deserves attention [13].

## **Conclusion**

Participation or assistance in the implementation of measures to create a healthy lifestyle and reduce the spread of RF of noncommunicable diseases of the environment of the population, carried out by the territorial center for medical prevention and other organizations. Dynamic monitoring of the contingent of people at increased risk of developing non infectious diseases and referring them to internist doctors. Being able to apply this technology into practice would allow us to conduct mass prenosological examinations of the population and improve the quality of targeted, personalized prevention of risk factors and their health.

## **Methods**

A prenosological examination of a person focuses on determining the level of vitally important functional capabilities of the cardio-respiratory, muscular, central and autonomous nervous systems, coordination-motor and morphological characteristics and regulatory mechanisms [5-8]. These results are important for determining predictors of the development of pathological conditions, identifying risk factors, and also for assessing the effectiveness of individual rehabilitation programs. Based on this data, and considering the individual characteristics of each person, to develop targeted preventive measures and programs for their implementation, ensuring the correction of identifying prenosological disorders and the prevention of the development of chronic non-infectious diseases that are relevant for maintaining healthy health.

Thus, in contradistinction to classical medicine in clinical and outpatient facilities, the object of prenosological diagnostics are, usually, healthy people. Their interest in this type of examination is determined, by the form and content of their conclusions and on the other hand it depends on the comfort of the applied diagnostic and correct technologies.

A comprehensive assessment of the level of prenosological functioning states of the body and indicators of its health and the application of the modern information technologies allows us to: create a data-bank of health conditions and conduct long-term automated monitoring of changes in the health of population, implement their correction, directed to the optimal and wide physiological and socio-psychological adaptation of the individual. Assess the impact of exogenous and endogenous effects on health and the effectiveness of ongoing health and corrective measures. When we talk about the remedies of health correction and disease prevention, it should be borne in mind that this entire complex is used at the preclinical stage and is designed for the mass consumer who does not have medical knowledge. Accordingly, we can only talk about means of non-pharmacological correction of health (a healthy lifestyle, a balanced diet, physical activity, personal hygiene, psychocorrection of communication, etc.). PD helps to develop systems of dynamic control over the health status of adults, even at home without going to a medical institution.

There are two methods:

- Prenosological screening is the selection of people with certain functional conditions for the subsequent resolution of issues of their recovery;
- Prenosological control - dynamic monitoring of the functional state of the healthy people.

Monitoring the health of individuals, that is, prenosological control, is a practical step towards assessing the state of regulatory systems in dynamics, identifying the very initial manifestations of their overstrain, both in the whole organism and in individual organs and systems, and correcting them in a timely manner. The volume of work, if the entire population is covered, will be tens of times more than now in the health care system, where work was done only with already ill parts of the population. Therefore, the implementation of monitoring health by conventional methods, using the capabilities available in the system, is difficult, and sometimes even impossible. The process of prenosological research in all cases

is a recognition process using both simple logical rules and complex mathematical techniques. But it is always standing out by non-invasiveness, comfort and short time of diagnosis. It is worth mentioning another important methodological principle of prenosological diagnosis, which is the use of information-intensive research methods. This means that with minimal examination time and its methodological simplicity, extensive and valuable information must be obtained that allows important conclusions to be drawn about the state of regulatory mechanisms, functional reserves and the level of functioning of the main vital systems. This principle is fundamental in the elaboration of specific technologies, the algorithm for its implementation and the rules and knowledge used in this process. In this regard, to tackle these problems, it is relevant to attract the modern capabilities of information and communication technologies, mobile communications, automated remote exchange methods, accumulation, storage of information, as well as mathematical methods and algorithms for their intellectual analysis. As a result of their application into the practice of mass surveys of the population, it becomes possible to develop and implement preventive measures, which are effective mechanisms for ensuring the preservation of health.

## Abbreviation

RF: risk factors; PD: prenosological diagnostics; TSBC: type of self-regulation of blood circulation; IFCh: index of functional changes; HR: heart rate; SAP: systolic arterial pressure; DAP: diastolic arterial pressure; BW: body weight; H: height; A: age.

## Declarations

**Authors' contributions.** Author Karabaev M.K. contributed an analysis of the literature on this topic and the relevance of the development and implementation of new approaches and methods that could improve the quality, reliability and targeting of prenosological diagnosis. He outlined the main areas of organization of mass prenosological examinations to assess the level of the functional state of the body of the population and the introduction of their systematic monitoring, early identification of risk factors and the implementation of preventive measures to correct them, ensuring the preservation health of fit persons. Author Abdumanonov A.A. contributed to the creation of algorithms, the structure of the database and computer program, the collection and analysis of data accumulation, storage of information, as well as the involvement of medical knowledge, mathematical models and algorithms for their intellectual analysis of data from a specific contingent of the population to provide remote automated monitoring of the prenosological level health in this research.

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**Availability of data and materials.** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Ethics approval and consent to participate.** This study was approved by the Fergana branch of the Tashkent Medical Academy.

**Consent for publication.** Not applicable.

**Competing interests.** The authors confirm that this article content has no conflicts of interest.

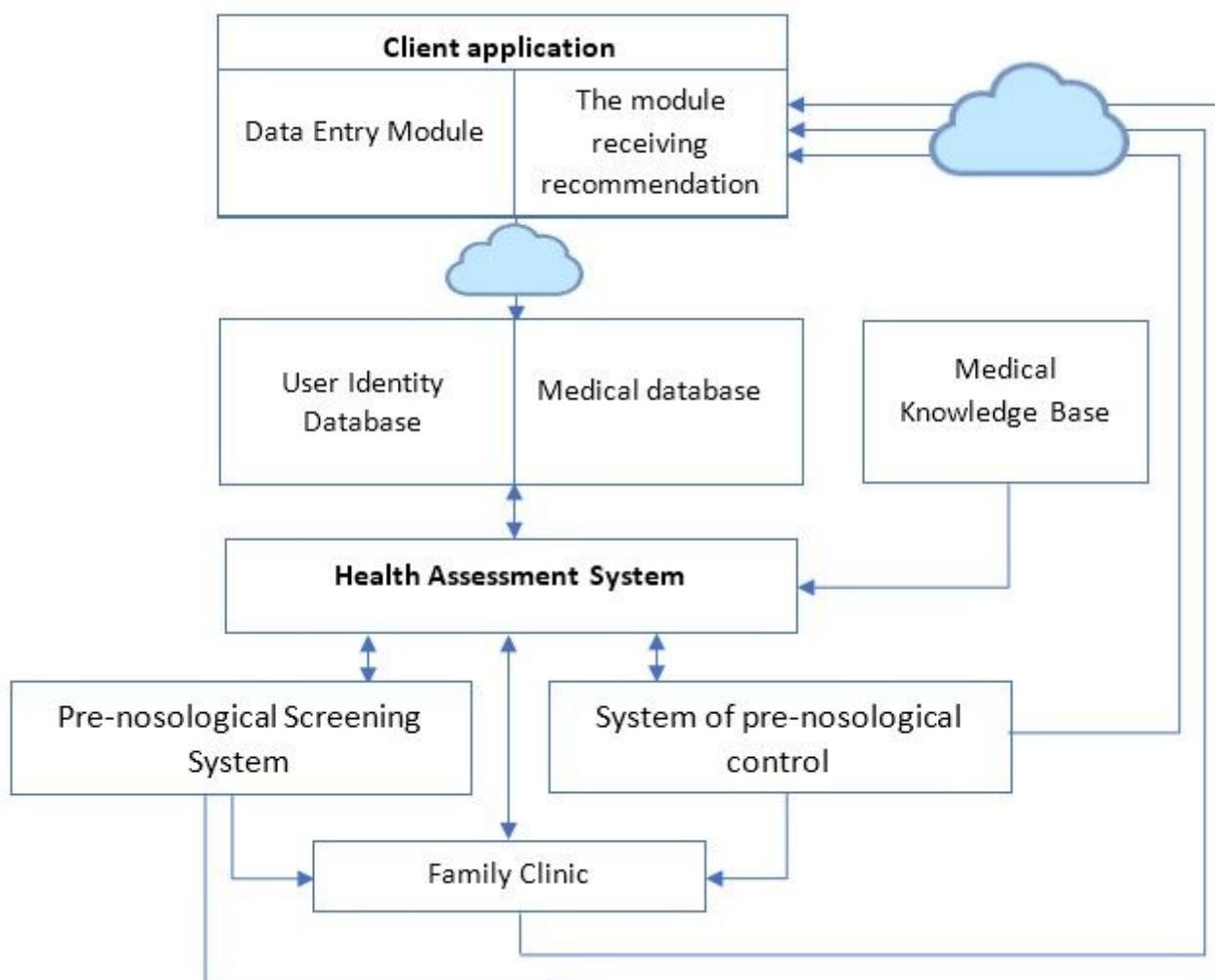
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## Figures



**Figure 2**

Structural scheme of the system