Optimization of medical information systems by using additional factors

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Abstract

Increasing longevity is one of the most important problems of modern Gerontology. Solution of these problems is connected principally with the use of information and communication technologies. Creation of a comprehensive health information system requires consideration of many factors, such as qualitative screening system based on patients' self-assessment, identification of possible errors that affect decision-making and patients' personal characteristics. The work presents the results of elderly Almaty and Almaty Region population survey conducted with the help of Active Longevity Portal designed for data collection, analysis and assistance to the elderly population of Kazakhstan. The results showed that the number of medical consultations is directly related to health self-assessment and anxiety levels. Detection of cardiovascular diseases (CVD) with the help of effort angina self-assessment demonstrated low sensitivity. Correlation between the Kettle's index of effort angina self-assessment, the impact of Physical Component Score (PCS) of SF-12 test onto the manifestation of cardiovascular disease in hereditary background, anxiety level and coronary heart disease manifestation, impact of Health Survey estimated by Physical Component Score (PCS) and Mental Component Score (MCS) SF- 12 test onto the correspondence between Effort Angina Questionnaire and CVD patient state was detected. Studies showed that detection of diseases through Questionnaire Survey self-assessment in certain situations may lead to significant errors. Consideration of these factors will help to build a more powerful information system in which personal data will be combined with clinical data and expert estimates.

Keywords: gerontology, Kazakhstan population, information technology, cardiovascular diseases, medical information system

1 Introduction: *Actuality of the research*

Gerontological research is associated with the rapid aging of the population in developed countries. This process is caused not only by the birth rate decrease, but also by a life expectancy increase. For example, according to European experts in 2060 one third of European population will reach age 80 or elder [1]. The same processes occur in Japan [2]. Researchers predict population decrease in China, India, Brazil, Russia and increase of older people number [3].

Kazakhstan is a developing country, but its population is also aging. In Kazakhstan, as of January 1, 2010 the number of people aged 65 years and older was 7.14% of the total population of the country. UN experts consider Kazakhstan to be the state with accelerated aging. By 2050 25% of elder people are expected in the country according to forecasts.

Because of this, Kazakh society faces the problem of active longevity prolongation reducing the costs of health care for elder people and increasing their demand in the labour market in old age.

Improving care for elder people, comprehensive solution of their medical-biological, social, and psychological aspects is one of the priorities defined by the State program "Salamatty Kazakhstan" for 2011-2015, approved by the Decree № 1113 of the President of the Republic of Kazakhstan d.d. 29.11.2010.

Economic analysis shows that it is necessary to find new methods and technologies, which will help to improve the quality of service and to reduce costs. Initiatives that are offered in different regions are usually connected with the use of information and communication technologies (ICT).

At the same time we have to point out that, the potential of ICT in Gerontological market is very high: the fact is that Europeans aged 65+ own funds over € 3,000 milliard [4]. In Kazakhstan, the situation is different, but due to the growth of elderly population (1,634,974 people by 2011), Internet usage increase, income growing, as well as increase of the number of

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specialists in the field of Gerontology and Geriatrics the potential of ICT will also be high.

With the introduction of principles of pharmaco-economic analysis and health-economic standards into the work evaluation of health care organizations, not only a correct statement of the clinical diagnosis and the reasoned purpose of treatment, but also prevention and prediction of diseases became very important in everyday medical practice.

An adequate solution to these problems is possible while optimizing Medical Information Systems (MIS). MIS, are the most important component of accounting and control of medical practice, they allow to maintain an electronic version of the medical record, plan research, obtain diagnostic information and provide data for scientific research.

In the medicine of the future, a pivotal role belongs not to the treatment of diseases but to their prevention and early prediction. With adequate prevention and prediction of diseases, it is possible not only to reduce morbidity, but also improve the economic performance of the healthcare system.

Despite the advances in modern medicine, the percentage of errors in medical practice remains high [5]. One of the purposes of computer systems is to support decision making to reduce the risk of erroneous diagnoses and treatment. In this case, Electronic health record (EHR) is the base, which contains comprehensive data for the analysis and development of medical science and practice. However, there are many challenges to be faced in the development of effective and adequate information system.

First of all it is necessary to standardize the basic set of data that will provide comprehensive health assessment, risk assessment and disease diagnosis, and will allow optimizing case management and solving problems of organization and control.

Cost-effectiveness of health is affected by many factors including frequency of patient address to qualified medical professionals and duration of treatment of diseases, which in turn depends on the accuracy of diagnosis and case management.

Multifunctional portal aimed to optimize the health care of the elderly population is being developed as part of the scientific and technical program of the Ministry of Health of the Republic of Kazakhstan [6].

The ultimate goal of the portal development is the creation of an information resource that will perform the following functions:

Function of questionnaire self-entry by patients or their relatives

Function to gather statistical information on the questionnaires from the portal database

Analytics function

Self-diagnosis function

Function of economic analysis and recommendations generation.

To implement the MIS first of all it is necessary to define the parameters which will be recorded in patients and will prove sufficient for the planned analytical and forecasting aims. This publication presents the first stage of the required criteria selection. Some issues related to the influence of personal factors on case management processes, which should be taken into account while designing both medical information system (MIS) and the EHR, are considered. The work consists of the following parts:

In Part 2 the basic functionality of the Active Longevity Portal as part of the MIS is discussed

In Part 3 the field of study and the methods are considered

In Part 4 the results of the research are presented.

In Part 5 the necessity of both clinical and other personal characteristics of the patients in the MIS design and the impact of the analysis on the development of the Active Longevity Portal is discussed.

In conclusion the results of the analysis and their impact on the development of MIS are summarized.

2 Objectives and functions of the portal

The portal is supposed to be an input point of "Gerontological space" of Kazakhstan including information about major aspects of Kazakhstan population aging. It will be a platform for experience exchange, publication of research results and reception of generalized and personified information about elder people health (Fig.1).

Based on the collected information using methods of scientific forecasting, searching patterns in the data and forecasting in processes of aging by experts in gerontology and geriatrics, expert systems on various aspects of aging process will be developed.

Portal users at this stage:

Doctors (managers for interviewers)

Interviewers (persons who gather and enter questionnaires)

Managers

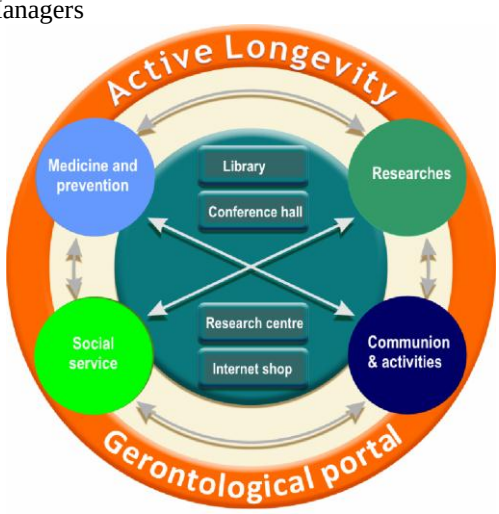

FIGURE 1 Functional interconnection of Active Longevity Portal

Portal functions at this stage are the following:

1. Questionnaires selection according to various criteria
2. Questionnaires input, editing and deleting
3. Retrieval of information about interviewers
4. Gathering of statistics from questionnaires entered into the data base.

Prospective users of the portal in the future (additional to initial portal users):

- Specialists in the gerontology
- Any other medical specialists, practitioners, interns, residents and graduate students
- Health facilities
- Sanatorium and rehabilitation centres
- Social services
- Elder citizens, their relatives and carers
- Organizations that use volunteer work

Any interested organizations and individuals, including entrepreneurs, merchants, sponsors and patrons, etc.

Health insurance

Medical equipment and medicine manufacturers and distributors.

Possible functions of the portal in the future:

- Function of questionnaire self-entry by patients or their relatives
- Function to gather statistical information on the questionnaires from the portal database
- Analytics function
- Self-diagnosis function
- Placement of scientific publications and scientific journal of the medical community
- Relation: patient - portal - clinic. Information exchange between the patient and the portal, the patient and the clinic, the clinic and the portal
- Portal users forum on Gerontology or other medical issues

3 Methods

This work contains analysis of the data obtained in the course of medical screening tests of residents of Almaty city and Almaty region (the Republic of Kazakhstan), which was conducted by the Active Longevity Portal. The study addressed two sets of problems. Firstly, the problems of healthcare on the medical examination of the population were considered. Secondly, the problem of designing a screening Internet-system and creation of a medical database and testing it on real data were solved. In total 3,032 people including 1,660 women and 1,372 men aged 36-94 were examined.

All data were entered into the developed information system and then exported for analysis in MS Excel and Statistica 8.0. The data were collected through the portal system Active Longevity.

To determine anxiety and depression there was used a self-assessment scale "Hospital Anxiety and Depression Scale" (HADS), which is designed for a screening identification of anxiety and depression [7]. Depending on the result of HADS all patients were divided into 3 groups.

To detect coronary heart disease (CHD) in population mass screening it is necessary to use standardized and reproducible methods. In this study a standard questionnaire of WHO which is widely used in the practice of population-based surveys was used to identify the effort angina [8].

Hereditary background was assessed in patient survey, recording diseases of their parents.

In Statistica 8.0 for multiple comparisons using ANOVA method there was used Tukey HSD for unequal N and Scheffe test, a rough criterion which is suitable for cases where there is a suspicion of inequality of variances between the samples.

To compare two proportions there was used Statistica 8.0, p-level is computed based on the t-value for the respective comparison.

4 Findings

4.1 THE INFLUENCE OF PATIENTS' PERSONALITY FACTORS ON THE ACCURACY OF CARDIOVASCULAR DISEASE (CVD) RISK ASSESSMENT

EHRs are focused on the automation of the treatment process, including the optimization of diagnosis and prediction.

A large number of publications indicate the influence of patients' personality factors on course and treatment of various diseases.

However, Health Organizations and EHR in particular, are frequently not directed to use patients' personality factors in the diagnosis and treatment. In the bibliography there are only a few reports on its impact and the need for inclusion of additional indicators that are better and can describe the patients' condition more systematically in the EHR standard [9, 10, 11].

Cardiovascular diseases are the most common indication for hospitalization among adults over 65 years [12]. CVD is a very common disease, one of the leading causes of death, as well as temporary and permanent disability of the population in the developed countries. According to WHO statistics the largest proportion of deaths is caused by cardiovascular disease (48 %) [13]. WHO recommends to conduct periodic health examinations to ensure timely detection of risk CVD. Screening is a common strategy in many countries to reduce the disease rate through early detection and intervention [14].

The fate of patients depends not only on the adequacy of the treatment, but also on the quality and timeliness of

diagnosis of the clinical forms of the disease, which require the emergent help or urgent hospitalization.

In preventive medicine for large-scale identification of individuals at risk of coronary heart disease questionnaire is often used. In the present study the hypothesis about the impact of some personality factors such as anxiety, Physical Component Score (PCS) and Mental Component Score (MCS) (SF-12) on questionnaire identifying the risks of coronary heart disease (CHD) is tested.

Increased anxiety indicates the patient's propensity to perceive an extensive range of life situations as threatening and respond with a large degree of anxiety. Anxiety disorders occur with 5-10% of the adult population and, for example, in case of myocardial infarction it happens 2-3 fold often [15].

The essential problem in identifying CVD can be low sensitivity of questionnaires used in screening. In the group under study 65.1% of the patients with CVD questionnaire revealed no effort angina. When the respondents were split into 3 groups with different levels of anxiety, it was found out that:

- with a low level of anxiety questionnaire method showed no effort angina in 83.1% of patients with CVD,
- with a high level of anxiety angina was not diagnosed in 43.3% of patients with CVD.

The results show that self-assessment of effort angina may not detect CVD of individuals with a normal level of anxiety. Z. M. Lohanova discloses [16] possible reasons for incorrect diagnosis of angina, which may be associated both with the patient's personality and inefficiency of diagnostic procedures.

In addition, the work states that the identification of symptoms and assessment of the severity of the disease may depend on the method of collecting information that is on self assessment or medical documents [17]. In particular, self assessment in the evaluation of cardiovascular system state proved to be less effective.

This paper presents the research of the influence of Health Survey, estimated with Physical Component Score (PCS) and Mental Component Score (MCS) of SF- 12 test, on the correspondence between the Questionnaire assessment of effort angina and patient CVD.

Analysis of the data showed that:

- at the high level of Physical Component Score questionnaire method showed no effort angina in 78.6% of patients with CVD,
- at the low level of PCS effort angina was diagnosed in 31.0% of patients with CVD.

Thus, with higher rates of Physical Component Score, as well as with self-anxiety assessment case self-assessment of effort angina cannot detect CVD in patients having it.

At the same time, no influence of Mental Component Score SF-12 on error rate was detected when using the questionnaire method for effort angina determination.

The research showed that the error rate with effort angina questionnaire estimation method may depend on Kettle's index (weight-height index), which is calculated as weight in kilograms by height in meters. Kettle's index allows to assess physical development and take into consideration body parameters of individuals (related to health, health care, diet, etc.).

Data analysis showed that 83.9% of the normal Kettle's index, as in the case of Physical Component Score, self gina can not detect the presence of CVD in patients with this disease.

4.2 SIGNS OF HEREDITARY TAINTED CVD

Hereditary background as well as identification of factors, which influence the development of hereditary tainted diseases are of great importance in disease prediction. The relationship between the level of anxiety and depression and the frequency of manifestations of hereditary tainted cardiovascular disease was revealed.

The study showed that:

- in the group of individuals who have parents with cardiovascular disease, the frequency of such diseases statistically significant ($p < 0,01$) was different in the groups with low, medium and high anxiety and was 52.9 % , 77.5 % and 100.0 % respectively.
- in the group of individuals who have parents with cardiovascular disease, the frequency of manifestations of cardiovascular disease statistically significant ($p < 0,01$) was different between the groups with high and low depression and was 60.8 % and 100.0 % respectively.

The influence of Physical Component Score (PCS) of SF- 12 test on manifestation of cardiovascular disease with hereditary background was revealed in the present work. In the group of individuals who have parents with cardiovascular disease, the frequency of manifestations of cardiovascular disease statistically significant ($p < 0,01$) was different in the groups with low and high PCS and was 80.0 % and 34.8 % respectively.

Observed relationship may be caused by various reasons, which will not be discussed in this article. In the perspective of this study, it is important that some of the personal characteristics of patients can significantly affect the appearance and course of various diseases, which, in turn, must be considered when designing medical information systems.

4.3 INTERCONNECTION OF MEDICAL CONSULTATIONS FREQUENCY AND PATIENTS' ANXIETY

The effectiveness of MIS effects the quality of healthcare, which, in turn, depends on the success of the solution of organizational and managerial tasks. Among these tasks, the most important are the processes of

optimization of medical work, which are based on forecasts of the medical consultations frequency, as well as prognosis of the number of medical staff with required qualifications and skills.

The research of the scientific sources shows that the behaviour of individuals depends on personal factors and cannot be unambiguously predicted for the entire population. Personal factors include features of the individual, which are not part of health changes or health indicators.

They are gender, race, age, social background, education, occupation, lifestyle, life experience, psychological characteristics, of which some or all may affect health, diseases and treatment of individuals. However, at present, organizational and managerial task are solved without taking into account possible influence of personality characteristics of patients. For example, in case of hypochondria, which can be a symptom of depression, patients pay too much attention to their health and have frequent complaints of malaise.

The hypothesis on the impact of the level of anxiety and depression on the frequency of patient's medical consultations was tested in the present study. Analysis of the data showed that the number of medical consultations is interconnected with the level of self-assessed health and disease rate and with the level of anxiety. It should be noted that the relationship between the number of medical consultations and anxiety levels was not observed in 55 year old patients and younger.

The following relationship was not different with men and women, so the graphs represent men and women over 55. Tukey HSD for unequal N and Scheffe test showed a statistically significant difference ($p < 0,01$) levels of self-assessed health and the frequency of medical consultations among all groups with different levels of anxiety (Fig.1., Fig.2.).

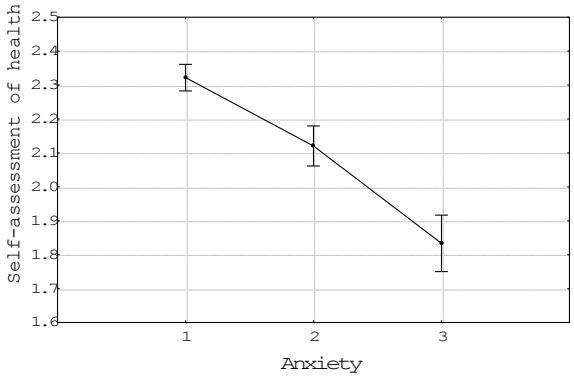

FIGURE 1 Graph of means and confidence interval (95.00%): levels of self-assessed health at different levels of anxiety

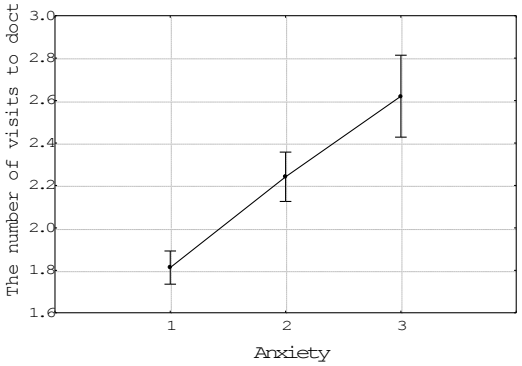

FIGURE 2 Graph of means and confidence interval (95.00%): number of medical consultations at different levels of anxiety

Number of medical consultations was statistically significantly higher at the lowest level of health self-assessment (Fig.3.).

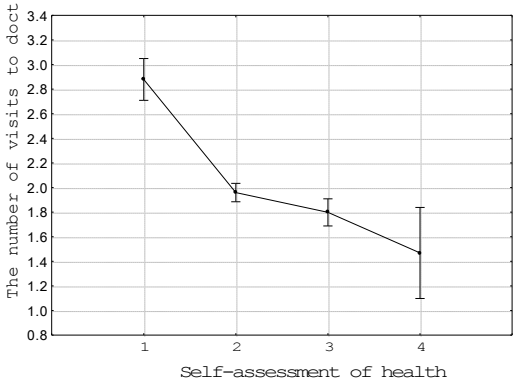

FIGURE 3 Graph of means and confidence interval (95.00%): number of medical consultations at different levels of self-assessment of health

Based on the data below, to exclude the effect of the level of health, the relationship of anxiety and frequency of medical consultations studied in groups with the same level of self-rated health.

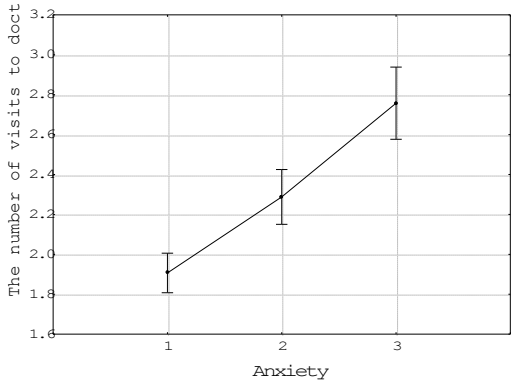

FIGURE 4 Graph of means and confidence interval (95.00%): number of medical consultation at different levels of anxiety in patients with health self-assessment 1-2 points

Analysis of the data showed that at the highest level of health self-assessment there is no influence of anxiety level onto the frequency of requests for medical aid. In contrast, at low levels of health self-assessment there was

statistically significant relationship between these parameters. The frequency of medical consultations was statistically significantly different between all 3-anxiety groups. On Fig.4 there is a graph for patients with health self-assessment 1-2 points.

The same statistically significant ($p<0,01$) relationship of anxiety level and frequency of medical consultations is observed if patients have three or more somatic diseases (Figure 5). At one registered somatic disease no dependence is detected between the frequency of medical consultations and patients anxiety level.

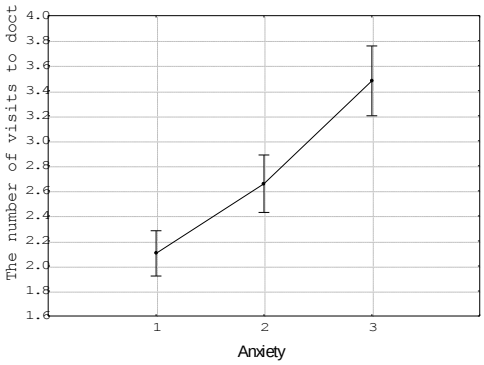

FIGURE 5 Graph of means and confidence interval (95.00%): number of medical consultations at different levels of anxiety in patients with 3 different diseases or more

The relationship between the frequency of medical consultations and the level of depression in patients with different health self-assessment and different number of reported cases was investigated. The analysis showed the following:

- results of men and women with a high level of health self-assessment (3-4 points out of 4) and with no or one disease showed no relationship between the frequency of medical consultations and the level of depression;
- results of women with low health self-assessment (1-2 points out of 4) showed the frequency of medical consultations to be significantly lower with low depression (group 1) than with moderate depression (group 2) and high depression (group 3) (Figure 6a);
- results of women with 3 or more diseases showed the frequency of medical consultations to be differed significantly in all groups with different depression, and it was lower in patients with low depression (group 1) (Figure 7a);
- results of men with low health self-assessment (1-2 points out of 4), the frequency of medical consultations was significantly higher in cases with high depression (group 1) than in cases with moderate (group 2) and low depression (group 3) (Figure 6b);
- results of men with 3 or more diseases showed the frequency of medical consultations to be statistically significantly higher at the high (group 3) rather than at low (group 1) depression (Figure 7b).

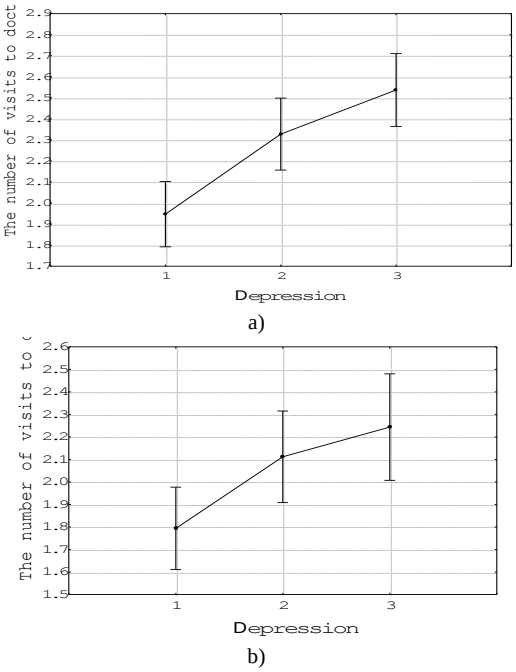

FIGURE 6 Graph of means and confidence interval (95.00%): number of medical consultations at different levels of depression among women (a) and men (b) with low health self-assessment 1-2 points.

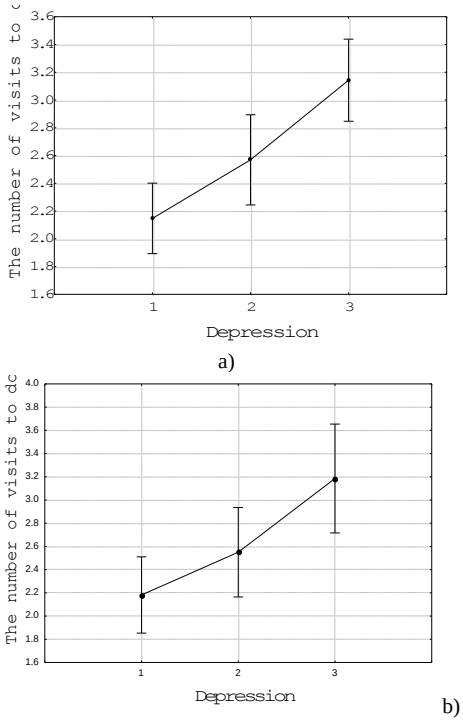

FIGURE 7 Graph of means and confidence interval (95.00%): number of medical consultations at different levels of depression among women (a) and men (b) with 3 and more diseases

These data indicate that the workload of medical staff can be determined not only by the level of disease, but also by psychiatric features of patients.

5 Discussion

The main purpose of medical information systems is ensuring effective information support of all members of the healthcare system in the process of management and of health care delivery.

In the present study there was confirmed the hypothesis that the personal characteristics of patients may have an impact on all phases of healthcare.

Economic Optimization of health depends on the timeliness and accuracy of diagnosis of diseases and their prevention, as well as the cost of patient management. An important prevention strategy is a permanent population health screening. The conduct and improvement of screening methods may not seem beneficial in some cases, but in general, the mass screening tests provide improved population health, if they meet certain principles [18]. However, the effectiveness of screening programs should be scrutinized and validated before implementation [13].

Population screening is not possible without the use of questionnaire methods. However, the study showed that the identification of diseases through self-assessment by questionnaire in certain situations can lead to significant errors and not reveal underlying disease or predict the probability of their occurrence. These issues must be considered when designing the EHR, as comprehensive qualitative data, which allow to develop and use complex methods to solve medical problems for the development of efficient algorithms for the prevention, diagnosis, and treatment are necessary.

Identified potential errors in the diagnosis of disease suggest that to improve the quality of diagnostic health monitoring it is necessary to evaluate personal characteristics of patients and take them into account at all stages of healthcare. Taking into consideration personal characteristics of patients, along with the dynamics of the recorded parameters should increase the sensitivity and specificity of diagnostic procedures, and efficiency of patient management. Computerization of healthcare industry, on the one hand, made it possible on the basis of the accumulated data build intelligent systems for management of patients. However, on the other hand, the construction of intelligent medical systems is impossible without a systematic approach to the assessment of the patient, which is, taking into account not only clinical, but also other personal characteristics of the patients.

Economic benefits of accurate diagnosis, including screening, conducted by MIS, and therefore based treatment will exceed the cost of developing high-quality information systems and a full diagnosis procedure [16]. Since in this case it will be possible to shorten the disability period, reduce the cost of beneficiary drug coverage, claims, various allowances, the disability cases, etc.

MIS, in particular, EHR with proper design and exploitation can be used to generate secondary data, which are necessary for the improvement of all medical procedures of forecasting before the treatment and rehabilitation of patients [19].

Results presented in this paper revealed only some of the problems that are necessary to be considered in the design and use of MIS. In particular, EHR developers should be focused on the expansion of the recorded performance and automation of complex assessments of patients with the use of a wide range of parameters, including personal factors. *It was shown that healthcare staff workload depends on the mental characteristics of the patients.* The data obtained are taken into account in implementation of the Active Longevity portal.

Therefore, for the collection of patients' personal characteristics data tests that determine some personal characteristics of patients were included into the system. This portal is currently used by professionals to collect and prior analysis of medical research data. Specialists who advise physicians in planning examinations recommended to use SF-12 test questionnaire as mandatory to determine anxiety and depression. In the future, we plan to expand the research methods of personality characteristics of patients in order to select the most relevant solutions for specific health problems.

6 Conclusions

The research showed that such indicators as anxiety, Physical Component Score (PCS) of SF-12 test and Kettle's index (weight-height index) can influence onto the probability of error in the identification of effort angina in screening surveys of patients and in the use of health self-assessment questionnaire. At low levels of anxiety, self-esteem does not reveal the effort angina in 83.1 % of cases, and at the high level in 43.3 % of cases with CVD patients. At a high level of Physical Component Score the error of effort angina detection was in 78.6 % of cases, with low PCS in 31.0 % of patients with CVD. Besides with the normal Kettle's index in health self-assessment CVD was not revealed in patients with this disease in 83.9% of cases. Based on the results it can be stated that the personal characteristics of patients may have a significant impact on the results of screening and preventive medical examinations, which use rapid surveys of patients and methods of self-assessment questionnaires. The necessity of usage of personal characteristics indicators of patients in clinical practice is also confirmed by other results of the study. Thus, it was revealed the influence of the level of anxiety and depression on the frequency of occurrence of cardiovascular disease in hereditary background of CVD; those patients with higher levels of anxiety and depression are much more likely to develop cardiovascular disease.

The results support the assumption that the effectiveness of MIS in solving medical problems such as the prevention, diagnosis, rehabilitation and forecasting, will depend on the inclusion into the system of both

clinical and personal characteristics of the patients. The results show that *personal characteristics of patients affect cost-effectiveness of healthcare:* with a lower health self-assessment and higher levels of anxiety and depression patients are more likely to seek medical help. Such behavioural characteristics of patients are not taken into account when planning medical staff workload, which can lead to higher actual workload of medical staff and health facilities. The results suggest that the lack of indicators collected in the databases of medical information systems can lead to serious mistakes in planning and management processes of healthcare.

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- Machine-learning techniques in pattern recognition rocks at uranium deposits. / Proceedings of the National Academy of Sciences of Kazakhstan, 2013, №3. С.82-88.
- Geophysical Research of Boreholes: Artificial Neural Networks Data Analysis. The 6th International Conference on Soft Computing and Intelligent Systems and the 13th International Symposium on Advanced Intelligent Systems, SCIS-ISIS 2012, Kobe, Japan, November 20-24, 2012, 978-1-4673-2743-5/12/$31.00 ©2012 IEEE, p.825-829

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- Variant Polymorphisms of GST and XRCC genes and the early risk of age associated disease in Kazakhstan World academy of science, engineering and technology. Internal Journal of medical, pharmaceutical science and engineering. 2012, **6**(11), 15-20.

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