Information system for evaluation of healthcare expenditure and health monitoring

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HIGHLIGHTS

- Current challenges and future perspectives of e-health for health care system.
- To provide a ground work on which future standardized training.
- Expenditures on health care throughout most of the developed world.
- There is evidence that e-health is important and that in successful management.

ARTICLE INFO

ABSTRACT

To discuss current challenges and future perspectives in order to initiate a debate on the introduction of implementation of information system (e-health) for health care system. The ultimate goal of the article is to provide a ground work on which future standardized training and credentialing curriculum could be based on. Health care issues have been the subject of intense scientific discussions around the world for the past two decades. Most attention is drawn to the efforts of interested countries to find the most effective way of control complex health care systems. Expenditures on health care continue to increase substantially throughout most of the developed world. There is evidence that e-health is important and that in successful management, the effects are correlated with management practices and promoted values. Clinical quality depends on e-health system, therefore implementation of new information system are necessary at all levels. The development of e-health competencies must be an integral part of the training and education of doctors. In this study a new e-health system was developed based on healthcare expenditure and economic development. There is currently a great necessity of a standardized e-health systems to be developed and applied with training and certification of current and future leaders.

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1. Introduction

Nations around the world organize and develop their health systems in accordance with their own needs and resources, which leads to great differences in experience and understanding. A good health system brings quality services to people around the world, whenever and wherever the need arises. Services themselves vary on a country basis, but generally require a robust funding mechanism; a qualified and financially satisfied labor; reliable information behind decisions and policies;

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adequate facilities and logistics to provide quality medicines and technologies [1,2]. The quality of health care in the Balkan countries today is far lower than the European average [3]. The health care system of Serbia has the highest number of employees in the region, but it allocates the least money for the sector [4]. As health care costs today are rising faster than the costs of other services, providers of health services in Serbia, especially the hospitals, are under constant pressure. The main challenges are increased costs and variations in quality. A major concern is also the return of invested funds. Faced with the financial crisis and fear of the unsustainability of the health system, there is a constant pressure from the authorities to reduce costs, although resources are becoming more expensive and the patients' expectations are increasing. The migration of medical personnel from Serbia is becoming a trend; the consequences are obvious and the expectations are unfavorable. The results of the research "Migration of health workers from the Western Balkans countries - analysis of the causes, consequences and policies" recently published by the Institute of Public Health of Serbia showed that health care workers on the way to other countries are mostly forced by low income, inability to get employed, job dissatisfaction, and by the position of doctors in the society, followed by the lack of conditions for professional development and career development, poor working conditions, poor organization and nepotism [5]. In order to tackle the challenges that the health system in Serbia faces today, a deep understanding of the resulting situation, the response of the competent authorities, the planned actions of the scientific community, and the concrete contribution of all stakeholders are needed. These are difficult decisions, and it is unclear what the right or acceptable solution is and what is not in such specific areas of human practice. One of the potential solution could be implementation of new information system or e-health system which will track all activities of patients and based on the activities the system will make recommendations for future treatments and behavior. Also the information technology is developed rapidly and there is need to implement the new technology in healthcare.

In paper [6] was soughed to assess the physicians' and patients' use of certain technologies and to predict their capability to adapt tools for e-health communication systems in the future. As the healthcare organization invest in information technology and develop needed capabilities, there is a need to understand the effects of these factors on performance [7]. While many fields such as Business, Marketing and e-Learning have taken advantage of the potential of gamification, the digital healthcare domain has also started to exploit this emerging trend [8]. The reform requires hospitals to adopt interoperable electronic health records (EHR) to facilitate data sharing and cooperation among healthcare providers, ultimately contributing to improvements in quality of care and efficiency in the health system [9]. However there are also some ethical issues raised by e-health [10]. In the 21st century, e-health is proving to be one of the strongest drivers for the global transformation of the health care industry [11]. In study [12], an extensive literature review was performed to compare e-health and other sectors in terms of the critical success factors in collaborative business process management. There have been questions raised about the security of the sensitive information such as health records as well as the privacy of involving parties raising doubts on the minds of the general public [13].

Therefore in this article an attempt is made to create information system (e-health) for the healthcare system. For such a purpose object-oriented methodology is used through rational unified process (RUP) [14,15]. The healthcare system should improve economic growth rate through gross domestic product (GDP) [16]. In this study healthcare expenditure is used as one of the most important indicator for GDP changing [17,18]. Computational intelligence technique is used for estimation of relationship between healthcare expenditure and GDP [19].

2. Methodology

2.1. Healthcare system perspectives

Based on the review of available literature, this article discusses knowledge flows on how e-health can affect the quality and sustainability of health systems and organizations. Health care service provider issues have been the subject of intense scientific discussions around the world for the past two decades. Most attention is paid to the efforts of interested countries to find out the most effective way of managing complex health care systems. There is a belief that management is important and that in successful management, the effects are correlated with management practices and promoted values [20]. Recent studies have highly underlined the importance of governance in the health sector: a positive correlation between clinical and economic performance has been found; e-health management can affect the quality and sustainability of health systems and organizations [21].

Of course, there are still many open questions, including the topic of managing a complex health care system. Globally, the view that medical organizations run by doctors are working better than others is dominant. The following benefits of medical engagement are highlighted: lower patient mortality rates, less serious incidents, maintenance of high level of service delivery and patient care, good financial status, achievement of set goals, maintenance of basic standards [22]. In Serbia, the healthcare system is traditionally administered by doctors. The Law on Health Care from 2010 allows the appointment of non-medical professionals as directors if the training on health services management has been successfully completed. This raises important questions about the role that doctors can and should have in creating the future of medicine in Serbia. There are a lot of dilemmas about how to increase, support and invest in the development of e-health skills. Scientific experts express doubt and warn that such efforts will not be enough unless accompanied by clear and long-term development of e-health skills through well-designed and regular education. Such education should not be an addition to the already complex process of medical education and training [23].

E-health means developing formal plans and monitoring results. The ability for medical (clinical) e-health system should be considered as an essential part of the development of professional competence among doctors, addressed at all levels

of their training. Medical e-health system is a key part of the professional work of a doctor, regardless of specialty and appointment. Therefore, doctors in Serbia should be more actively involved in the planning, provision and transformation of health services [24]. It is their duty to contribute to the development of the institution in which they work and to fulfill what society needs in the future. It is a way for a doctor to stay in touch with clinical reality, and at the same time to plan its future in the form of new ideas and current projects.

In recent years, especially due to the pressures of financial crisis, there is an increasingly obvious need for a broader perspective on the quality of health services. It seems that clinicians and managers can no longer work in isolation, because every manager-clinician conflict is regularly transformed into a competition for resources [25].

At the macroeconomic level, health is a factor that has direct implications for the proper conduct of life and economic and social activity. Health is "the collective value of a higher interest". The health of each individual and the nation is directly proportional to their quality of life. The quality of life is defined as the perception of individuals about their own position in life in the context of the culture and system of values in which they live, as well as according to their goals, expectations, standards and interests. It is a broad concept made up of individuals' physical health, psychological status, financial independence, social relations and their relationship to significant environmental characteristics. Our consciousness is the one that principally shapes quality of life, health, and ability. What people more and more strive for is inner satisfaction. Happiness is the primary goal of human existence [26]. At the international level, welfare improvements are increasingly seen as an alternative to increasing gross national product (GNP) as a measure of progress and the nation's goal. One of the leading nations in the debate on welfare policy is Britain where Parliament established working groups for the welfare economy, which points to the view that well-being has become an arena for political debate. The UK government launched in 2015 a new advisory center based on evidence of well-known "What Works". The purpose of the Center is to provide guidance to national, regional and local policy makers and other stakeholders on best welfare improvements in the UK, and to encourage stakeholders to make decisions based on the impact of different political options on the welfare of the nation [27].

Currently everything happens 20 times faster than a few decades ago. Our spiritual growth and maturation are also accelerating, and in addition, healing is faster. However, health care planning is often described as evolutionary rather than revolutionary. The change is the nature of reality. We are all in the path of personal change and the simultaneous changing of the world around us. But no problem can be solved at the same level of consciousness on which it originated (Einstein). This is achieved by gaining insight into his abilities — spiritual development, self-evolution. For the development and training of employees in this direction, the most successful companies in the world allocate as much as ten percent of total income. In Serbia, only about one or two percent is allocated for such needs. Increased awareness and flexibility lead to the revitalization of both personal and professional life, and personal and professional development go hand in hand with each other. Quantum physics has confirmed the importance of the level of consciousness and intent of the individual — the force behind everything created. Therefore, health organizations, wherever they are, should now provide quality health care in a holistic and integrated way with the help of clinicians and managers. The characteristics of quality health care are: efficiency, accessibility, equality, safety and effectiveness. All this with a focus on the patient is a platform in which clinicians and managers can identify clinical and operational processes that would enable them to provide health care in a desirable, comprehensive way. Its major weakness is that it turns holistic medicine into art rather than science because the physician must master the intention, which is a poorly understood dimension of existence. Also, the treatment and management of complex health systems requires a constant compromise between the need to reduce costs and improve the quality of health care, which greatly slows down the process of progress and the expected improvement [28,29].

It has become a familiar cry in recent years that more doctors should take up senior management and leadership roles in the health service. Some countries, such as Australia, Canada and the UK, already have medical education and developed competency frameworks for management and leadership. Broader literature on leadership suggests that some leadership behaviors are universally supported, but there are also those that are culturally determined. At the global level, debates are still ongoing, how to coordinate medical education with changing socio-economic needs and organizing health systems. Most health systems continue to face multiple challenges during the management process. For example, the intelligent use of information technology has become essential for effective leadership. Health informatics has developed over the years and is one of the important pillars in providing quality health care. IT systems of the European health sector, compared to other industries, are still not at a desirable level. The challenge of the digital world cannot be seen only as a challenge, but as a future perspective [30,31].

Doctors in managerial positions are important for hospital performance. The question arises what role they can and should have in creating the future of medicine. Considering the great investment in time and resources necessary for their training, it is reasonable to investigate whether placing future physicians in leadership roles is a valuable investment. There is a prediction that a large number of doctors who now perform the tasks of managers will soon retire, and that leadership competencies among young doctors must be developed. The conclusion of the assessment of leadership education indicates that there are serious shortcomings in the number and quality of leaders [32,33].

Health care management and leadership is essential, but neglected aspect of medical training in Serbia. Changes in curricula and innovation are inevitable parts of progress in undergraduate and postgraduate studies in medical education. Lack of training promotes poor decision-making and inadequate health services that negatively affect end users. An integrated approach to the management of health care and education of medical leadership at the undergraduate level is needed in order to enable physicians to be effective leaders who manage resources in an appropriate manner and in
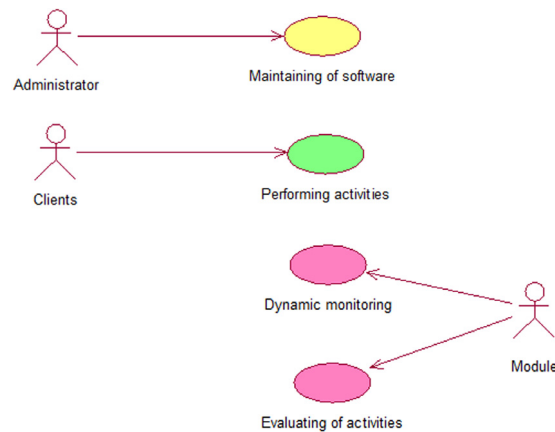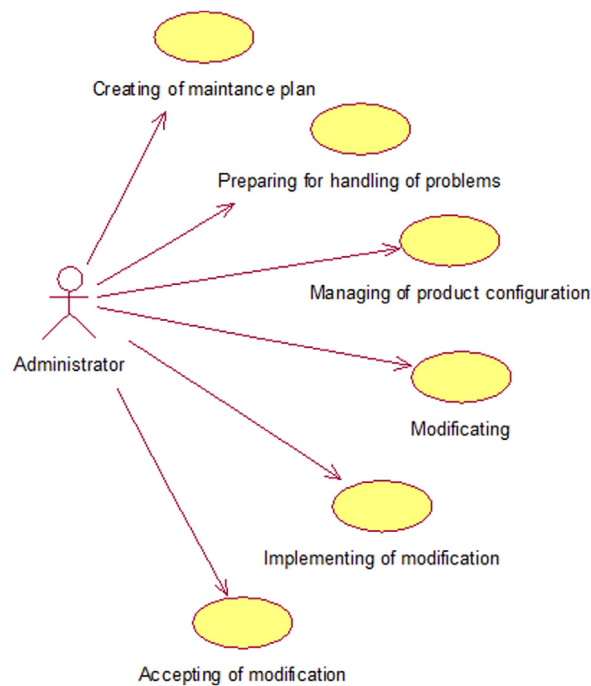
Fig. 1. E-health system.

Fig. 2. Use case diagram of the software maintaining.

accordance with quality requirements. The health care system today needs to provide quality health care in a holistic and integrated way with the help of clinicians and managers [34,35].

Discussions of the future of medical education and the need to include training that allows doctors to contribute to the management, maintenance and reform of health care delivery models, continues the debates that have taken place since the introduction of new public governance reforms. It was found that the leadership of a physician can improve the performance of the health care system in terms of: social responsibility (community contribution), adoption of reforms and information technologies, management of financial and operational resources, quality of care (including health outcomes, patient safety and experience of care) and staff satisfaction and their retention. The situation that physicians at the head of the health care teams of significant clinical systems in Serbia requires that more attention is paid to managerial and leadership skills. What we need to know is why and how to increase, support and directly invest in the development of clinical leadership in Stabia; define the role of a doctor, their organizational and clinical responsibility, and how they can be educated to fulfill what society needs in the future [36].
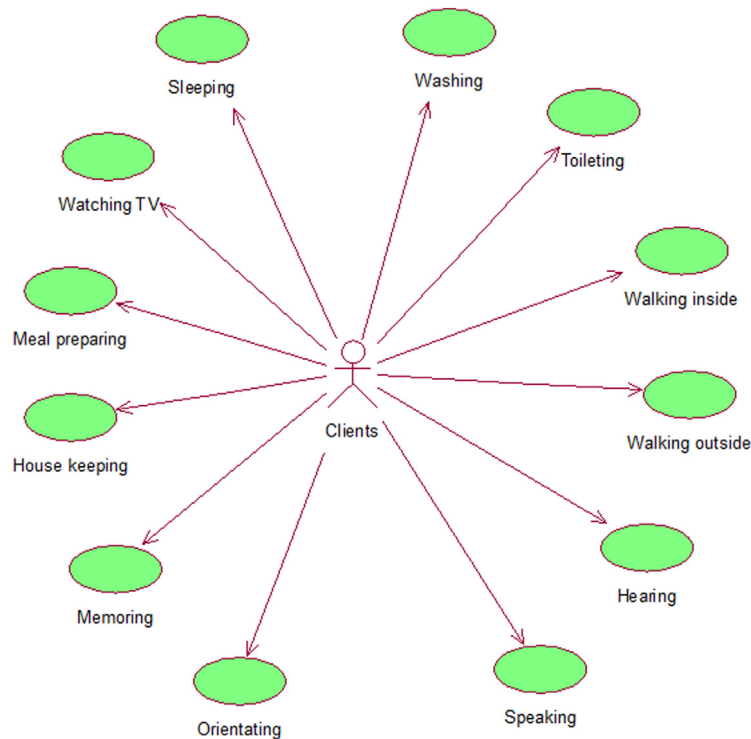
Fig. 3. Use case diagram — Performing activities.

Although the implementation of healthcare changes has been known as challenging, change management experts rarely choose to support it. They argue that organizational readiness for change is a critical obstacle to the successful implementation of the initiative for change.

2.2. E-health modeling

In this article rational unified process (RUP) [37] is used for the health care information system modeling process. This is a proven methodology which is used for different aspects of the system modeling. RUP is an interactive and iterative methodology which are based on modeling of system architecture. RUP methodology is based on Unified Modeling Language (UML). UML is based on object-oriented concepts.

There are four phases in RUP methodology. In the first phase the main requirements of the system are identified and documented. Main users and use cases of the system are identified in the first RUP phase. Use cases are one full sequence of users' actions. By the use case one can define desired behavior of the system. However the desired behavior not need to be achieved in the final product. In this study health system modeling is based on use cases modeling through use cases diagrams.

2.3. Health expenditure analysis by ANFIS

Adaptive neuro-fuzzy inference (ANFIS) is applied for estimation of health expenditure relevance on economic development in European Union. EUROSTAT database is used for creating of input/output data samples. MATLAB software environment is used for application of ANFIS procedure.

ANFIS represents on kind of artificial neural networks merged with fuzzy logic inference. There are five layers in the ANFIS network and each of the layer has specific role during training and checking procedure. The most important task is to select fuzzy logic membership functions before training procedure of ANFIS network. After trial and error process bell-shaped type of membership function is selected since this functions produces the best results. For training and checking procedure hybrid learning algorithm is used.
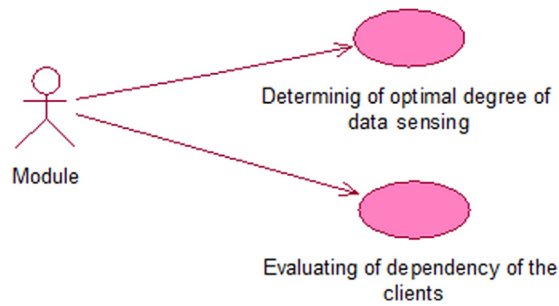
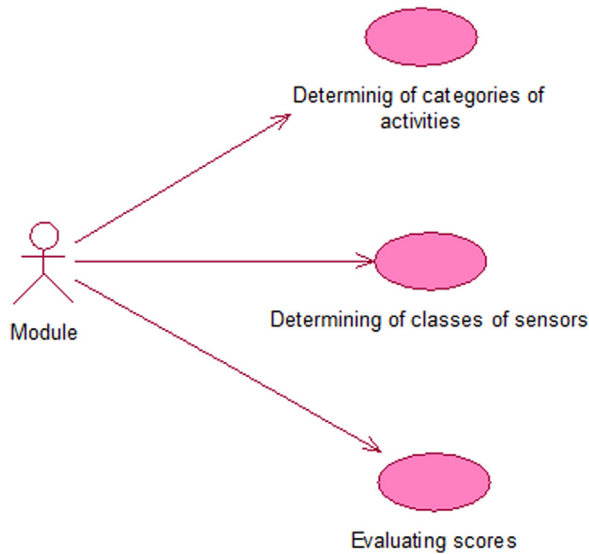**Fig. 4.** Use case diagram — Dynamic monitoring.

Fig. 5. Use case diagram — Evaluation of activities.

3. Results

3.1. E-health system

The e-health system is modeled by use case diagrams. The diagrams could show the dynamical behavior of the system. Fig. 1 shows the main use case diagram of the system. There are three subjects of the e-health system: client, module and administrator. The administrator should maintains of the software of the e-health system. Clients of the e-health system are patients. As can be seen the clients should perform some daily activities only. The module of the e-health system should perform dynamical monitoring and evaluation of the activities. Each of the use cases will be presented separately by detailed use case diagrams.

Use case diagram for software maintaining is shown in Fig. 2. The administrators should:

- Create of maintenance plan,
- Prepare for handling of problems,
- Manage of product configuration
- Modify
- Implement the modification
- Accept the modification

Use case diagram for performing activities is shown in Fig. 3. Each of the activity has defined specification in the e-health module.

Use case diagram for dynamic monitoring is shown in Fig. 4. The use case is performed only by module of the e-health system. First of all the module should determine the optimal degree of the data sensing and finally to evaluate dependency of the clients. By the determining of the optimal degree of the data sensing it means to avoid unnecessary data by data ranking
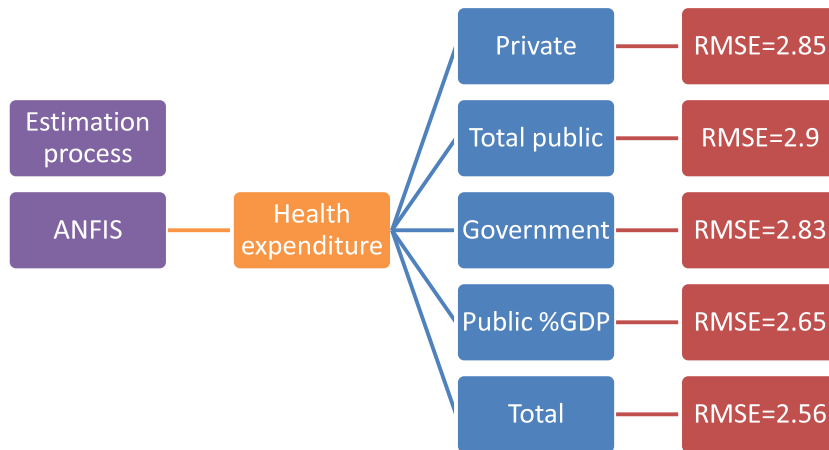
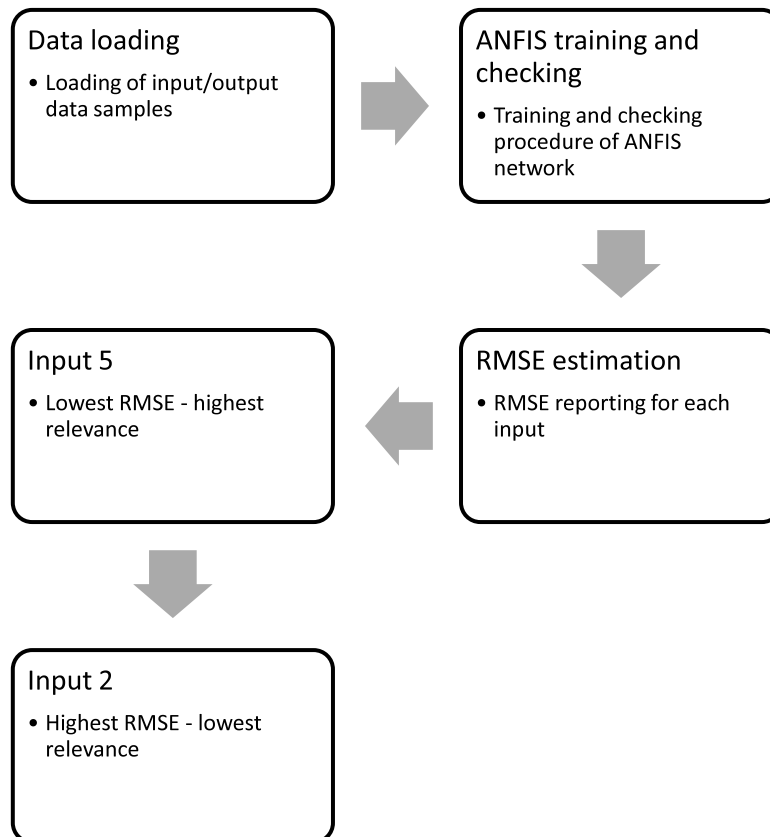**Fig. 6.** Health expenditure correlation with economic development.

Fig. 7. ANFIS procedure.

or by sensitivity analysis. The second use case should evaluate the dependency of the clients based on analyzed data. Such evaluation could simplify future evaluation process since many clients has same or similarity treatments.

Use case diagram for evaluation of activities is shown in Fig. 5. There are three use cases in the diagram. The first use case represents determining of categories of activities. It means each activity should be categorized based on their frequency. The second use case represents determining of classes of sensors. In other words based on sensors frequency, some sensors will increased sensing capability and some sensors will decreased the sensing capability. It means there is no need for all sensors

to be activated 100% whole time. The third use case represents the evaluating of activities. It means the module will evaluate the clients' activities and based on the evaluation the module will recommend future treatments and behavior of clients.

3.2. Health expenditure analysis

Fig. 6 shows the correlations between health expenditure and economic development for European Union. There are six parts of the health expenditure. Each of the part has different relevance with the economic development. One can note the total health expenditure has the smallest RMSE hence the strongest relevance with economic development. Fig. 7 shows total ANFIS procedure for estimation of the correlation between health expenditure and economic development.

4. Conclusion

In this article current challenges and future perspectives of the healthcare system are considered and discussed. The main goal is implementation of information system (e-health) for healthcare system. The ultimate goal is to provide a ground work for future. Health care issues have been the subject of intense scientific discussions around the world for the past two decades. Due to rapid development of information technology there is trend to introduce the technologies in health care system as well

Clinical quality depends on e-health system, therefore implementation of new information system are necessary at all levels. In this study a new e-health system was developed based on object-oriented methodology.

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