Impact of Information and Communication Technologies (ICT) on Health Care

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Abstract

ICT has an impact on many aspects of health care. The most important are accessibility to health care services by citizens, economical aspect and quality of care aspect.

The main goal is to provide access for the citizen at any time and in any place. eHealth can certainly provide such an access especially in the regions where physician may not be available.

The continuously rising costs are the main problem of the contemporary health service in many countries. These costs may not be acceptable both for developing and developed countries. eHealth can decrease the costs of health care by decentralizing the care - enabling medical services at a lower level where they are cheaper (e.g. regional hospital instead of university hospital), or by avoiding patient transport to the hospital when it is not necessary.

The improvement of the quality of care has been demonstrated in several medical disciplines e.g. cardiology. The transmission of ECG signal directly from the ambulance to invasive cardiology centre significantly improved Acute Coronary Syndromes patient diagnostics and reduced time from the onset of symptoms to intervention.

In developed countries the phenomenon of ageing population is evident. It is estimated that the cost of health care of that group is 60% of the total cost. How eHealth can cope with that problem? The answer is by home monitoring and telecare. The patient data can be trans mitted over the cellular phones to the medical centre and evaluated by the physician. Home monitoring is applied in many types of diseases such as cardiac failure, hypertension, diabetes, COPD. The preliminary results show that in many patients the number of exacerbations and hospitalizations is decreased. The care is therefore improved and costs diminished.

eHealth can cope with the deficit of medical staff in developing and the developed countries. Teleradiology is a good example. The images are transmitted to the location where radiologist on duty is available.

ICT has an impact on education of both patients and medical staff. There are many www sites aiming at prevention of civilization diseases (diabetes, hypertension, cardiac failure, cancer). They can support groups of patients suffering from the same disease (e.g. cancer patients). The effect of e-learning cannot be overestimated as far as medical education is concerned. There are many e-learning courses and videoconferences on variety of topics. The Medical Virtual Universities are established. The best model of learning for medical sciences is blended learning. It is a combination of traditional learning with e-learning. The contact with a real patient is a core of the learning process in medicine.

The shift from medical services to prevention and health promotion can be observed. ICT applications in health care should adapt to the new situation.

Keywords: eHealth, ICT, impact, accessibility, quality of care, economy, education

1. Introduction – ICT and Health.

The term eHealth refers to the use of modern information and communication technologies (ICT) to meet needs of citizens, patients, healthcare professionals, healthcare providers, as well as policy makers [1].
The role of World Health Organization (WHO) is very important in promoting and advancing eHealth. At 58th session in May 2005, the World Health Assembly (WHA) adopted a resolution WHA 58.25 establishing eHealth strategy for WHO.
The WHO Report for the World Summit on the Information Society in Tunis (2005) underscores the close link between health and ICT: "Today, ICT is fundamental for health systems to meet obligations to deliver care, pursue research, educate students, treat patients and monitor public health" [2].
The Global Observatory of eHealth (GOe) was created by WHO. GOe undertook a world-wide survey on eHealth [3]. The key findings of the survey were that:
• active involvement, of WHO in the development of generic eHealth tools, and guidance in creating and implementing eHealth services would be welcomed by the Member States;
• the need for guidance in a broad range of eHealth areas was expressed in particular by countries that do not belong to the Organization for Economic Co-operation and Development (OECD);
• OECD countries did not express consistent views of their needs in eHealth areas;
• there is a need to raise awareness as to what eHealth tools and services already exist at global and national levels.

The Observatory's mission is to improve health by providing Member States with strategic information and guidance on effective practices, policies and standards in eHealth. Its objectives are [3]:
• to provide timely and high quality evidence and information to help national governments and bodies improve policy, practice and management of eHealth services;
• to raise awareness and commitment of governments and the private sector to invest in, and advance eHealth;
• to collect, analyze and distil eHealth related knowledge, which will significantly contribute to the improvement of health using ICT;
• to disseminate research finding through publication of the GOe Annual Report on key eHealth research topics as a reference for governments and policy –makers as well as theme based reports on special topics.

The WHO Report for the World Summit on Information Society [2] indicates inequity between burden of disease and spending in developed and developing countries.
Health conditions and ICT diffusion in countries provide a basis for outlining opportunities for action in eHealth .
Health conditions can be expressed by WHO's mortality strata.

United Nations Conference on Trade and Development (UNCTAD) has established an ICT diffusion index which is used in this report. ICD development is based on connectivity, access and policy. These terms are defined as follows:

Connectivity : Physical infrastructure available to a country: per capita internet hosts, PC's, telephone mainlines and mobile phones. Excludes electricity, broadband, and affordability measures.

Access : Number of internet users, adult literacy rate, cost of a local call, and GDP per capita

Policy : Comprises presence of internet exchanges, competition in the local loop / domestic long distance and competition in the internet service provider market.

ICT diffusion index can be calculated from the formula:

ICT diffusion = (Connectivity + Access+ Policy) /3

ICT diffusion takes on values from 0 to 1 range (eg. Iceland has the highest ICT diff in Europe = 0,76);

Table 1. ICT diffusion – summary.

Region	**Max ICT diffusion**
Africa	0,36 Mauritius
South East Asia	0,33 Maldives
Americas	0,80 USA
Europe	0,76 Iceland
Eastern Mediterranean	0,58 United Arab Emirates
Western Pacific	0,68 Singapore

Low ICT diffusion value for a given country indicates obstacles in eHealth development. Better telecommunications infrastructure, more reliable and user friendly access devices are of a high priority in developing countries.

2. History. Major achievements in ICT for health care.

The first applications of ICT in health care were hospital information systems (HIS) in the United States [4] . They were: Medinet project at General Electric followed by work at

Massachusetts General Hospital (MGH) in Boston. In parallel the work on HIS was done at LDS Hospital, Salt Lake City, Utah by Warner and at Kaiser Permanente in Oakland, California by Collen and by Wiederhold at Stanford University. The first HIS' were centralized systems using large computers (mainframes) (in the 60's) which later evolved to modular systems (in the 70's) and finally, after computer networks were developed, to distributed systems (in the 80's).

Italy is the cradle of telemedicine as the medical assistance from the International Radio Medical Centre to the crews of sea going ships started here in 1935.

ICT brought spectacular achievements to medical diagnostics. Two well known imaging techniques – computer tomography (CT) and magnetic resonance imaging (MRI) are based on computer reconstruction of images from management data.
The inventors of both techniques won Nobel prizes (Cormack, Hounsfield – 1979 (CT), Lauterbur, Mansfield -2003 (MRI).

Computed tomography (CT) mathematically reconstructs an image from X-ray attenuation values that have been measured from multiple angels. It is possible to view cross-sectional slices through the body and not 2 dimensional projections of superimposed structures [5]. Thus CT images provide a precise mapping of the internal structures of the body in 3 dimensional space which was not possible with standard radiography. CT greatly improved contrast resolution as well.
In basic CT imaging technique patent is placed between the X ray source which generates a beam and detector. The difference is the measure of X-ray attenuation by the tissue which is traversed by the beam.The source and detector are translated and rotated about the patient, and the X-ray attenuation is measured along each path.
The ability to see non invasively inside a living body was a revolution in medicine.

MRI started from Nuclear Magnetic Resonance (NMR) spectroscopy, technique which is used for characterizing the distribution and chemical environment of nuclei within a chemical sample. Nuclei (eg. ^{1}H, ^{31}P) have magnetic moment and behave as the small magnets [6]. Placed in a strong magnetic field they can accept several different energetic states because their magnetic moment can be oriented in concordance or against the field. Reorientation or changes of the states are accompanied by emission or absorption of the energy in the form of the electromagnetic pulse.
In medical applications it is mainly hydrogen nucleus ^{1}H , the main component of water. Patient is placed inside a magnet generating a strong magnetic field. The radio frequency pulse is superimposed on the constant magnetic field and only those nuclei which have the corresponding resonance frequency to the field intensity value are excited. Nuclei quickly return to the low energy state emitting radio frequency pulses. They are registered by special antennas. On the basis of data of magnetic field intensity, parameters of exciting radio frequency pulse and received pulses emitted by the nuclei it is possible to determine spatial density distribution of nuclei or a nuclei map.The slices and 3D reconstruction images are possible.

The functional MRI (fMRI) is a breakthrough in neuroradiology. It enables the combination of the information on morphology of the brain with data on reaction of chosen centers in the brain on external stimuli, fMRI opens the possibility for understanding the pathological processes in psychiatry, neurology and complement the brain image in neurosurgical planning. Introduction of ultra fast MR sequences allows for investigations at stopped breathing (apnea) performed especially in cardiac investigations . Cardiological MR (CMR) is the fastest developing application of MR which can be used for dynamic

investigations of perfusion, vitality and contractility of cardiac muscle, qualitative and quantitative coronary flow assessment.
The disadvantage of MRI is worse than in CT bone imaging because bones contain a small amount of ^{1}H nuclei (a small amount of water).

3. Impact of ICT on aspects of health care.

The characteristic trend is the change in health care paradigm which is based on the shift from medical services to disease prevention and health promotion. According to some sources [7] the UK only 80% premature health diseases, stroke and type 2 diabetes could be avoided by prevention and health promotion. ICT therefore should be applied in concordance with the new paradigm.
ICT has an impact on many aspects of health care. The most important are: accessibility to health care by citizens, its economy, quality of care and education.

3.1. Accessibility

The ICT has an impact on accessibility to health care services. The main goal is to provide access to the health services for the citizen at any time and any place and especially for the patients from rural areas and small towns.
eHealth obvious advantage in remote or rural areas is the improved access to health services eliminating sometime the need for a patient to travel to a distant hospital. The examples can be given from many parts of the world eg. Alaska - largest US Telemedicine Program, Ontario, Canada, Polkowane, Northeast Region of South Africa, Northern Norway, Azerbaijan and Armenia [8].

eHealth can provide access to medical services in emergency situations on board of a ship or a plane, where it may be impossible to get a medical care.
Improved access is related to all levels of care i.e. primary, secondary and tertiary and also means access between and within those levels. The possibility of obtaining the consultation in university hospital by the regional hospital is a good example.
Improved access means also equity of access to care between and within regions [9]. No longer urban centers are privileged in access to specialized services.
Apart from access to health services also access to information for both health professionals and patients can be mentioned. Access to large medical databases such as Medline is available within seconds via the Internet. These databases are crucial for continuous medical education (CME) which improves the skills of health professionals at all levels.
Information for non health professionals can be divided into two categories:

- information for general public as part of health promotion or health education to people, schools and health care centers. Such information serves the purpose of prevention of the diseases and indicates the relationship between the lifestyle and quality of life,
- information for patients explaining their diseases, prognosis, diagnostic investigations and treatment procedures. It helps shared decision making among patients and health professionals.

3.2. Economy

The continuously rising costs are the main problem of the contemporary health service in many countries. These costs may not be acceptable both for developing and developed countries. eHealth can decrease the costs of health care by decentralizing the care - enabling medical services at a lower level where they are cheaper (e.g. regional hospital instead of university hospital), or by avoiding patient transport to the hospital when it is not necessary.

In the developed countries the phenomenon of ageing population is evident. It is estimated that the cost of health care of that group is 60% of the total cost. How eHealth can cope with that problem? The answer is by home monitoring and telecare. The patient data can be transmitted over the cellular phones to the medical centre and evaluated by the physician. Home monitoring is applied in many types of diseases such as cardiac failure, hypertension, diabetes, COPD. The preliminary results show that in many patients the number of exacerbations and hospitalizations is decreased. The care is therefore improved and costs diminished.

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3.3. Quality of care

The imaging techniques described earlier (CT, MRI) contributed significantly to better quality of care. The primary use of imaging is diagnostics [5]. The other uses are assessment of patient status in terms of response to treatment and prognosis. CT is often used for surgery or radiotherapy planning. Images can also provide real time guidance during surgical procedures. Images enable remote viewing, interpretation and consultation thus are the means of communication. Imaging plays an important role in education, training and research. The link between good quality images and quality of care is evident.

The improvement of the quality of care via eHealth has been demonstrated in several medical disciplines eg. cardiology. In the study [10] the transmission of ECG signal directly from the ambulance to invasive cardiology centre significantly improved Acute Coronary Syndromes patient diagnostics and reduced time from the onset of symptoms to intervention. Only 40% of patients with ECG transmission over mobile phone from the ambulance required transport to the hospital and invasive cardiology procedure called percutaneous coronary intervention (PCI) . PCI significantly reduced patient mortality from 17,7% to 4,4% ($P<0,0001$).

Example of the improved quality of care was shown in the study on transmission of CT scans of neurosurgical patients [11]. Authors compared 50 referrals made without teleradiology to 66 referrals made following teleradiology and found a 21% reduction in unnecessary transfers and a significant reduction in adverse events during transfer (8% vs 32%).

In Chronic Disease Management (CDM) program in New Zealand [12] it was reported that the number of diabetic patients with glycosylated hemoglobin $HbA1_C>9$ % was:

- pre-enrolment 34%,
- post-enrolment 7%.

Therefore the number of patients with not adequate control of diabetes indicated by high $HbA1_C$ was significantly reduced. In normal subjects $HbA1_C$ is ca 6%.
Also 80% reduction of waiting time for statins for type 2 diabetic patients was achieved.

3.4. Education

ICT has an impact on education of both patients and medical staff.

There are many www sites aiming at prevention of civilization diseases (diabetes, hypertension, cardiac failure, cancer). They can also support groups of patients suffering from the same disease (e.g. cancer patients).

The effect of e-learning cannot be overestimated as far as medical education is concerned. There are many e-learning courses and videoconferences on variety of topics. E-learning is being described as revolutionary approach in presenting and transferring knowledge, which will be quickly developed in the upcoming future. There are several opportunities which stand for this point of view:

- creation of interactive model of learning, which stimulates knowledge acquisition,
- flexibility in both time and location , while accessing content presented on-line,
- appropriate use of innovative IT technologies in learning process,
- possibility of cooperation among teachers and students from different schools.

The Medical Virtual Universities are established. The best known is International Virtual Medical School (IVIMEDS) established in 2002 as a not for profit organization [12]. There are 26 participating universities from all over the world - Europe, North and Central America, Asia and Australia. IVIMEDS embraces the continuum of medical education including undergraduate, postgraduate and continuing medical education (CME).
The IVIMEDS principles are[13]:

- the use of world class learning materials accessed and shared among leading international medical schools and institutions,
- flexibility in choice of content and learning strategies and the ability to customize content to meet specific needs of teachers, doctors and students wherever they are located,
- technical interoperability and standards maximizing the scope of international collaboration and flexibility of delivery methods.

IVIMEDS delivers a high quality medical education service with e-learning resources and educational services to its partners. IVIMEDS partners can:

- contribute and access learning resources from a repository of learning objects,
- use the IVIMEDS map as framework for storing and accessing learning resources,
- use virtual patients from a virtual practice,
- use content in different learning contexts and with different learning strategies,
- use different e-learning systems and tools and to ensure compatibility with all of these systems emerging international e-learning specifications and standards are being adopted.

The best model of learning for medical sciences is blended learning. It is a combination of traditional learning with e-learning. Such model is used by the International Virtual Medical School (IVIMEDS).

Multimedia, virtual reality and simulations of different types are opportunities given by e-learning.
The most common form of e-learning in medical education is the Internet use which includes such elements as computer simulation, virtual reality (VR), virtual lectures, electronic textbooks and journals, organization of Continuing Medical Education courses, exams and virtual conferences . The Supercourse [14] consists of a Library of Lectures comprising 623 lectures created by 5000 academicians from 118 countries. Lectures are divided into 3 main categories: epidemiology, public health and special diseases. Lectures are available in a variety of languages, including Japanese, Chinese and Russian.
The benefits of computer simulation are significant particularly as far as doctors training in modern diagnostic and therapeutic techniques is concerned.
The most challenging factor in e-learning in medicine is lack or limitation of interpersonal contact, which is crucial in training future physicians.

4. Examples of eHealth benefits

The spectacular success of the use of ICT in public health is the control of river blindness or Onchocerciasis Control Program (OCP) in West Africa [15]. The effective reliable and appropriate information and communication system was required for collection of data critical for surveillance of the disease (the black fly larvae living in about 50 000 km of the waterways). OCP used sensors placed in waterways for periodic readings and transmission via satellite to the main center in Ounagadongou, Burkina Faso. It optimized the decision making for technical operations (eg. aerial insecticide spraying by a small fleet of helicopters) and for program coordination and management.

U.S. Government Accounting Office studied benefits of eHealth in 11 public and private Health Care Delivery organizations of varying sizes and settings (rural/urban) that had invested significantly in e-Health [16].
They were:

- 50%-80% reduction in medication error rates,
- >15% reduction in laboratory and diagnostic imaging tests due to online access to results,
- 30% increase in use of formulary and generic drugs,
- significant reduction in time to refer patients using online scheduling and communication tools,
- 40% increase patient screening and preventative health care procedures,
- 40% increase in use of standard protocols by physicians.

5. Conclusions

- The shift from medical services to prevention and health promotion can be observed. ICT applications in health care should adapt to the new situation,
- The advantages of eHealth implementation are numerous: better access to health care services, cost containment, better quality and safer care, possibility of e-learning for undergraduate and postgraduate medical education,

- Health is increasingly seen as a driver for – as well as beneficiary of – ICT development,
- Universities and health institutions can implement eHealth in research, education and clinical practice,
- Combination of demographics, health statistics and ICT indices is vital for developing eHealth strategy for each country.

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