The Impact of Information Technology on Quality of Healthcare Services

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Abstract. The incorporation of information technology tools in medical practice results not only in opportunities related to improved quality and availability of services but also in transformation of the model of care delivery. Spreading use of the computer applications in healthcare is propelled by the growing expectations of citizens about quality of medical care. Furthermore, modern healthcare system relies on the concepts of patient's empowerment, shared care and continuity of services. The fulfilment of all these requirements may be possible through establishment of the e-health environment allowing for safe "electronic" contacts between physicians and their patients. In turn, the use of telemedical applications improves the process of information exchange between professionals representing different referential levels and areas of medicine. The awareness of the fact that medical errors themselves may be meaningful cause of morbidity and mortality, accelerated searches for effective countermeasures. The use of computer-based solutions is perceived currently as one of the effective remedies. The paper explores the opportunities of improvement of healthcare performance and quality with solutions brought by information technology.

1 The Role of Information Technology in the Vision of Modern Healthcare

The perception of healthcare has been evolving from the moment when humans started to perform conscious actions for preserving health and treating ailments. The approaches based on the irrational beliefs or individual experience of practitioners were substituted by evidence-based clinical practice in 20th century. Simultaneously, radical changes in lifestyle and nutrition had profound impact on life duration and quality of life. The expenditures for healthcare remain important part of national products in developed countries. Increased awareness of health-related problems results in high expectations about healthcare performance among the citizens. The increased life duration, the emphasis put on maintaining high quality of healthcare services, the sophisticated medical technology and high incidence of chronic conditions in modern societies add to growing trends in healthcare expenditures.

The progress in telecommunication and computers science leads to essential transformations in other domains. The great expectations about opportunities for increased cost-effectiveness and quality of services exist also in healthcare. Information technology opens the window for assuring appropriate healthcare quality obtained within reasonable costs. Particularly, rapid growth of Internet community is

perceived as the factor which will radically change the model of health services delivery. The traditional approach to medical care requires substantial changes, if vital health-related needs of developed societies are to be fulfilled. Traditional codes of practice in medicine put stress on direct contacts between the physician and the patient. The form of this contacts is frequently defined by appropriate legal regulations. However, there are many forms of healthcare services in which traditional approach could be modified with the use of modern tools of communication. The best examples of such services include follow-up visits of chronic patients, monitoring of symptoms severity or educating patients about their diseases. In this context, it is understandable that the patient with established diagnosis, remaining under long-term control of his or her physician, returning for the consecutive visits does not require detailed history taking and physical examination on every occasion. Instead, the physician should focus on issues raised by the patient and problems that are priority in the context of the individual patient and specific disease.

The communication between the patients and health professionals may be considerably enhanced as questions raised by the patients are answered without the visit to physician's office. The doubts about disease course may appear quite often in patients anxious about their health status, and the digital platform of communication offers more flexible approach to the provision of explanations by health professionals. Simultaneously, the change in the forms of patient-physician communication brings new challenges to formal and legal regulations of standards of care.[1] The use of electronic communication for routine contacts between physicians and the patients is associated with some risks, but generally, it may be perceived, assuring technical feasibility and security of the specific technical solution, as convenient substitute for repeated visits of the patient in the physician's office performed for checking the patient's status and renewing prescriptions.[25] Internet and e-mail as new modes of communication between patients and physicians allow for greater flexibility and optimum use of health professionals' time.[24]

The Internet-based applications have also the potential for improvement of clinical practice services through better timing, adjustment according to patient's needs and integration of evidence-based guidelines in the information systems, e.g. in the form of decision support tools. After first clinical trials, it became obvious that even severe conditions may be efficiently treated at home providing appropriate communication with the patient as well as monitoring of vital signs and symptoms via telemedical infrastructure is assured. Teleconferencing system may be installed in patient's home and used by the patient with assistance of family members or social workers.

The inclusion of patients in the process of diagnostics and therapy is perceived nowadays as one of the key conditions of successful care.[30] Their active role in monitoring of disease severity became the obvious aim of medical management in chronic conditions, such as diabetes, bronchial asthma or arterial hypertension. However, self-observations and self-measurements conducted by the patients should be supported by interaction with health professionals having the access to patients' data. The Internet and telecommunication links shape perfect environment for such activities. Extensive use of web technologies for chronic care is possible in those societies which have appropriate access to Internet. The rapid growth of the mobile telephony penetration brings another tool suitable for telemonitoring applications.

The Internet health-related platforms are devoted to various aspects of chronic care. The website focused on specific disease offers many opportunities for improvement of care effectiveness. Patients are able to enter their self-observations and self-measurements results on-line but they can also receive answers to questions on every day activities related to their medical conditions without going to physician's office.[13] Simultaneously, health professionals can monitor health status of their patients through monitoring centre.[11] The process of monitoring may be enhanced with the feature of alert triggering in case of deterioration of parameters monitored by the patient prompting for appropriate action from the physician.

The Internet users surfing on the Web frequently use it as the source of health-related information.[16] The consumers of health services search for information about specific disorders, providers or health programmes as well as for contacts with support groups. The WWW-based medical record gives the patients access to his or her data from home environment.[31]

Self-education is important opportunity for chronic patients related to the widespread use of Web-based applications. Internet technologies enable individualised education and training process. More advanced solutions emerge the patient in the environment supporting self-management of the medical problem but also imposing the regularity of activities. In such environment the patient gains self-assurance that in case of deterioration the appropriate information will be forwarded to healthcare provider.

Full exploration of advantages related to the use of information technologies yields many other fields of application in healthcare such as the implementation of preventive measures, the efficient use of individual genetic information in early stages of health-supporting interventions (e.g. lifestyle modification, diet, avoiding specific factors), the transformation of the traditional contacts between health professional and patients and development of virtual support environments for people with special needs. The clinical care incorporates new modes of services delivery through the use of systems supporting electronic healthcare record, telemedical applications or electronic prescribing. Telemedicine offers broad spectrum of clinical scenarios enabling the e-visits for patients, teleconsultations between health professionals representing different medical centres or specialities, telepresence and teletraining in interventional specialities or even virtual surgery. The availability of information system in medical facility enables the implementation of reminding and alerting applications or decision support tools enhancing the quality of the process of care.

2 Improvement of Patient Safety

The awareness of the incidence of medical errors exploded with the report of the Institute of Medicine from USA published in 1999.[23] The main issue emphasized in the report was the great magnitude of the harm resulting from medical errors, the importance of appropriate organization of healthcare services in avoiding medical errors as well as the need for mandatory reporting programmes. The conclusions included in the Report were based on the publications in peer review journals issued in preceding 10 years. The data from this publications allowed for the estimations

about the consequences of medical errors on national scale in USA. The most shocking information was realization that even 98000 deaths annually may be related to medical errors. In 2001, the next report of the Institute of Medicine, titled "Crossing the Quality Chasm" was published.[21] The six aims for improvement indicated in this report include safety, effectiveness, patient-centeredness, timeliness, efficiency and equity. These aims may be approached with the application of information technology tools.[4]

The positive role of technology in reduction of the incidence of medical errors should result in broader use of such solutions, like bar-coding of medication, wireless PDA devices for access to patients record and drug information as well as systems for drug order entry. Among the most frequent adverse effects occurring in healthcare, first three places are hold by adverse drug events, nosocomial infections and procedural complications.

Adverse drug event are the largest, single category of medical errors. Medication errors are responsible for considerable number of physician's office visit and hospitalizations. The broader use of computer applications should be particularly effective in diminishing the number of adverse drug events related to medication errors. Three type of solutions are proposed in this context: computerized physician order entry (CPOE), automated dispensing machines (ADMs) and computerized medication administration records (CMARs).[22] The use of information systems, especially in the areas where automation process is available, is perceived as the way of errors containment in medical management. CPOEs offered in the IT market are able to detect negative drug interaction, unexpected shifts of dosage or conflicts between medication and medical conditions.[5], [26] Another important solution influencing three most frequent types of adverse effects in healthcare is the use of bar codes. [27]

The use of e-prescribing systems in outpatient practices should be encouraged as their implementation is potentially beneficial for patient safety and efficiency of management.[8], [9] The main benefits include the generation of legible and accurate prescriptions checked for harmful interactions, adherence to guidelines and health programmes as well as the option of access to patient information and availability of decision support functions at the point of care.

It is also obvious that great global impact on incidence of medical errors would have the widespread use of electronic medical record systems with functions of order entry, medication administration records and decision support than implementation of many single-purpose applications.

3 The Improvement of Access to Health Care Services with Telemedicine

Telemedicine means delivery of healthcare services conducted with the application of teleinformatic infrastructure. Advanced telemedical system or network enables diversified forms of medical services and information transfer among institutions and health professionals when direct contact is impossible. Telemedical system should fulfill such criteria as geographic distance between centres which exchange medical

information and the use of teleinformatic technologies as substitute of direct contacts. This type of services is also called telehealth, cybermedicine, or more recently, e-health. The appearance of new definitions of telemedicine is related to continuous development of this domain and finding new areas of applications for teleinformatic technologies.[7]

First telemedicine implementations were developed in 50-ies of 20th century. Telemedicine underwent considerable evolution from this time.[29] Today, telemedicine is perceived not only as the way of delivery of healthcare services in some extreme circumstances (as geographic isolation or emergency states) but more as the use of modern telematic tools for improvement of availability and quality of medical services. The use of telemedical application is not even over the world. Paradoxically, developed countries seem to be more devoted to establish telemedical applications in their healthcare environments as they see potential substantial benefits from their implementation. These benefits became more obvious due to rapid growth of the population of Internet users as it offers less expensive, more homogeneous and easily available technology to population. Even if benefits from the growing use of Internet in healthcare are very convincing, there are some issues which require careful recognition e.g. problems related to security and confidentiality of the e-health communications. The assurance of the quality of healthcare services delivered by Internet is also important issue.[10], [28]

Telemedicine employs various types of technical solutions. The systems available today include store-and-forward applications, videoteleconferencing systems and applications based on the WWW technologies. Store-and-forward applications are used in asynchronous mode as some time elapses between the moment of data transfer and their interpretations. Such system may be used for transmission of patients data to consultant who, in convenient moment, will read them and respond to questions.[3], [20] Store-and-forward systems are usually used in situations, in which videoteleconferencing contact is not necessary for efficient telemedical interaction or available telecommunication have limited band of transmission. This may occur in rural, peripheral locations without advanced telecommunication infrastructure.

Real-time interactions are possible in videteleconferencing systems.[18] Multi-point teleconferencing infrastructure enables numerous participants involvement in the teleconsultation sessions. Tumor boards appointed for making decision on oncologic problems are good example of such telemedical services.[6] Videoteleconferencing telemedical scenarios require broadband connections to enable the transmission of high volumes of data. They usually rely on the use of ISDN lines or fiberoptic links.[14] Specialistic peripheral equipment is used for registration of medical images and other types of data (stethoscopes, otoscopes, dermoscopes or whole body examination cameras). Document cameras enable the transfer of data which are not available in electronic form.

There are no single technology which could satisfies all requirements of specific implementation. The successful realization of telemedical scenario depends on choice of technology which satisfies users' requirement related to the volumes of transmitted data and band of the connection. Appropriate choice of teleinformatic infrastructure is also dictated by the scale of available financial support in healthcare system.[12], [19]

4 Chronic Care – Evolving Models of Care Based on Telemonitoring

Chronic diseases became the major health burden in developed countries. The estimations made all over the Europe and in the USA indicate that even 70% of health care expenditures is spent for management of chronic diseases in these areas. The number of patients suffering from chronic conditions is growing, but simultaneously a great number of them want to conduct active professional and social life. This results in the need for the improved efficiency of health care systems. The patient's role in the therapy and symptoms control, the importance of close patient follow-up, community services and prevention are not emphasized properly in healthcare systems as they served for years mainly for the provision of care to patients with acute illnesses.[32] The use of Internet technologies in health services provision in chronic care brings new opportunities and potentially cost-effective models of care.[15] E-health environment offers additional characteristics to modern healthcare through shaping new types of relation between patients and physicians, enabling automatic screening for exacerbations of disease, and creating the network of support for the patient.

The increase of the population of patients requiring chronic care and monitoring became the factor triggering the search of cost-effective but safe, health services delivery models. The rapid adoption of Internet in many domains brought also the promise for improvement of efficiency of healthcare delivered to patients with chronic diseases. The WWW technologies seem to be particularly feasible to obtain the appropriate level of interactivity for chronic patients.[2], [17] Patient empowerment means his or her involvement in prolonged observations of disease course, conducting self-measurement of parameters essential for specific disease. The main trace of self-management in chronic diseases is based on registration of self-observations and self-measurements in long-term perspective. Prolonged tracing of physiologic parameters enables the description of the course of disease and forecasting of exacerbations. Self-observations and self-measurements may be the basis for automatic triggering of alerts sent to health professionals and patients. Trend observed in the disease course are also the basis for modification of medication by the patient (self-adjusted treatment).

5 Summary

The traditional relation between physician and patient underwent considerable changes in last decades. The interactions between patient and healthcare system evolved to various forms. There is also the increasing pressure on healthcare providers to deliver services of high quality in cost-effective manner. The wider use of information technology in healthcare brings new opportunities for healthcare services delivery observing evidence-based approach.

The achievement of desired features of modern healthcare, such as seamless and shared care as well as continuity of care may be supported with web-based and mobile applications. Internet adds considerably to the concept of pervasive services,

especially in the area of chronic care. Patients with chronic conditions became the main consumers of healthcare services and telemonitoring services is new efficient way of care delivery in this population demanding frequent interactions with healthcare providers. Computer-based applications are also perceived as important solution enabling the reduction of medical errors. The access to limited specialized medical resources may be enhanced due to telemedical application. Their use increase also the collaboration within clinical team taking care of individual patient and formed by health professionals based in various institutions.

References

1. Balas A.E., Jaffrey F., Kuperman G.J., Boren S.A., Brown G.D., Pincioli F., Mitchell J.A.: Electronic Communication With Patients: Evaluation of Distance Medicine Technology. *JAMA* 1997; 278(2): 152-159
2. Balas E.A., Iakovidis I.: Distance Technologies of Patient Monitoring. *BMJ* 1999; 319: 1309
3. Bangert D., Doktor R.: Implementing store-and-forward telemedicine: Organizational issues. *Telemed. J. e-Health* 2000; 6(3): 355-360
4. Bates D.W., Cohen M., Leape L.L., Overhage J.M., Shabot M.M., Sheridan T.: Reducing the frequency of errors in medicine using information technology. *JAMA* 2001; :299-308
5. Bates D.W., Leape L.L., Cullen D.J., Laird N., Petersen L.A., Teich J.M., Burdick E., Hickey M., Kleeefield S., Shea B., Vander M., Seger D.L.: Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA* 1998;280: 1311-1316,
6. Davison A.G., Eraut C.D., Khan N., Haque S., Tanqueray A., Trask C.W., Lamont A., Uppal R., Sharma A.: Telemedicine for lung cancer: a new multidisciplinary approach. *Thorax* 1999; 54(3): A37
7. DeBaake M.E.: Telemedicine has now come of age. *Telemed. J.* 1995; 1(1): 3-4.
8. Elison B.: Electronic Prescribing in Ambulatory Care. *J Manag Care Pharm* 2001;7(2)
9. E-Prescribing. California Healthcare Foundation. November 2001
10. Ferguson T.: Digital Doctoring – Opportunities and Challenges in Electronic Patient-Physician Communication. *JAMA* 1998; 280(5): 1361-1362.
11. Field M.J., Grigsby J.: Telemedicine and Remote Patient Monitoring. *JAMA* 2002; 4: 423-425
12. Field M.J.: Telemedicine: a guide to assessing telecommunications in health care. National Academy Pr. Washington, 1996.
13. Forkner-Dunn J.: Internet-based Patient Self-care: The Next Generation of Health Care Delivery. *J Med Internet Res* 2003; 5(2): e8 [url:<http://www.jmir.org/2003/2/e8>]
14. Galvez P., Newman H.: Networking, videoconferencing and collaborative environments. *Comp. Physics Communications* 1998; 110: 43-50
15. Gillespie G.: Deploying an I.T. cure for chronic disease. *Health Data Manag* 2000; 8(7): 68-74
16. Glick T.H., Moore G.T.: Time to learn: the outlook for renewal of patient-centred education in the digital age. *Med Educ* 2001; 35: 505-509
17. Gomaa W.H., Morrow T., Muntendam P., Smith G.: Technology-based disease management: A low-cost, high-value solution for the management of chronic disease. *Dis Manag Health Outcomes* 2001; 9(10): 577-588
18. Gustke S., Balch D.C., Rogers L.O., West V.L.: Profile of users of real-time interactive teleconference clinical consultations. *Arch. Family Med.* 2000; 9(10): 1036-1040

19. Harrison R., Clayton W., Wallace P.: Can telemedicine be used to improve communication between primary and secondary care? *BMJ* 1997; 313(7069): 1377-1381.
20. Houston M.S., Myers J.D., Levens S.P., McEvoy M.T., Smith S.A., Khandheria B.K., Shen W.K., Torchia M.E., Berry D.J.: Clinical Consultations Using Store-and-Forward Telemedicine Technology. *Mayo Clinic Proceed.* 1999; 74(8): 764-769
21. Institute of Medicine: Crossing the Quality Chasm. A New Health System for the 21st Century. National Academy Press, Washington, DC, 2001
22. Kilbridge P., Welebob E., Classen D.: Overview of the Leapfrog Group Evaluation Tool for Computerized Physician Order Entry. Leapfrog Group and First Consulting Group, 2001
23. Kohn L.T., Corrigan J.M., Donaldson M.S. (eds): To Err is Human: Building a Safer Health System: a report from the Committee on Quality of Healthcare in America. Institute of Medicine, National Academy of Sciences. National Academy Press, Washington, DC, 1999
24. Leslie S.: Online consulting. The experience of a commercial service. *J Telemed Telecare* 2001; 7(Suppl. 2): S2:78-82
25. Mandl K., Kohane I., Brandt A.: Electronic Patient-Physician Communication: Problems and Promise. *Ann Intern Med* 1998; 129(6): 495-500
26. Mekhjian H.S., Kumar R.R., Kuehn L: Immediate benefits realized following implementation of physician order entry at an academic medical center. *J Am Med Inform Assoc*, 2002; 9: 529-539
27. Patterson C., Cook R., Render M.: Improving Patient Safety by Identifying Side Effects from Introducing Bar Coding in Medication Administration. *J Am Med Inform Assoc* 2002; 9: 540-553]
28. Stanberry B. The legal and ethical aspects of telemedicine. 2: Data protection, security and European law. *J. Telemed. Telecare* 1998; 4: 18-24.
29. Strode S.W., Gustke S., Allen A.: Technical and Clinical Progress in Telemedicine. *JAMA*; 281(12): 1066-1068
30. Tattersall R.: The expert patient: a new approach to chronic disease management for the twenty-first century. *Clin Med* 2002; 2(3): 227-229
31. Tsai C., Starren J.: Patient Participation in Electronic Medical Record. *J Am Med Ass* 2001; 285(13): 1765
32. World Health Organization "Innovative Care for Chronic Conditions: Building Blocks for Action. Global Report." 2002