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EVOLUTION OF TELEINFORMATION SYSTEMS APPLIED IN HEALTHCARE: FROM TELEMECIDINE TO HEALTH 2.0

Introduction

Medicine and e-health tend to adopt new technologies. With the advance in information and communication technologies new opportunities emerged to provide health services. They made it possible to replace the traditional direct contact between patients, doctors and technical devices. Despite the resistance of various groups, the increasing availability of new IT and communication tools, the expansion of the Internet and the omnipresent wireless networks resulted in a revolutionary change in the way how health services are provided. It is difficult to show a service in an information society that would not be electronically available. Thus, the expansion of digital services in healthcare is the consequence of general trends in various areas of human activity. A rapid application could be observed of the new communication opportunities for medicine that were provided by telegraph, radio or telephone[1]. Some of these technologies were used in healthcare for many years – one could mention here phone telemedicine, which in fact was a widespread form of telemedicine in the whole 20th of century; a fact that few of us are aware of[2]. Despite the first attempts to apply communication technologies in healthcare that started already in the 19th century, a significant progress in the development of telemedicine could be observed as late as in the second half of the 20th century, particularly at the end of the century. The term e-health appeared with the development of the Internet and by some people it was regarded with disrespect as a symptom of healthcare commercialization while the others considered it a crucial key to define the opportunities that can be provided to healthcare by ITC systems. The Internet changed not only the ways and

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[1] M. Sosa-Iudicissa, R. Wootton, O. Ferrer-Roca, *History of Telemedicine* [in:]: O. Ferrer-Roca, M. Sosa-Iudicissa (ed.), *Handbook of Telemedicine*, IOS-Press, Amsterdam 1998, pp. 1-17.
[2] R. Wootton, *Realtime telemedicine* [in:] R. Wootton, J. Craig, V. Patterson (ed.), *Introduction to telemedicine,* CRC Press, 2nd Edition 2006.

speed of communication but it also contributed to the change in the communication model. In a short time from sole passive recipients of information we changed into its creators. The Internet provides every user with the chance to publish their own messages. This involves new opportunities but also threats to people that need medical assistance. The development of online community and the possibilities to publish people's own information about health constitute after e-health a new dimension of ITC development in healthcare which is referred to as Health 2.0.

1. From telemedicine to e-health

For many years telephone was the most frequently used technical instrument of communication in telemedicine. Some authors even claim that the first telephone conversation that was made between its inventor Alexander Graham Bell and the assistant Thomas Watson on the 10th March 1876 had a character of a telemedicine contact[3]. Whether it is true or not, one must admit that telephone became for many years the main means of remote communication that was used for medical purposes and it met the requirements of the definition of telemedicine that was formulated later.

The first definitions of telemedicine were formulated 100 years later in the early 1970s. Kenneth T.Bird defined telemedicine as *the practice of medicine without the usual physician-patient confrontation via interactive audio-video communications systems*[4]. K.T.Bird's definition lacks the reference to the application of IT technologies as the platform to provide contact between the participants of a telemedicine session. This is due to the fact that the first telemedicine systems, which were developed in early 1950s, were based on TV technology. The application of IT systems was introduced to the definition of the telemedicine system by Rashid Bashshur as late as in the mid-1970s[5]. He listed six criteria for a telemedicine system: geographic separation between provider and recipient of information, use of information technology as a substitute for personal or face-to-face interaction, staffing to perform necessary functions (including physicians and technicians), an organizational structure suitable for system or network development and implementation, clinical protocols and normative standards of

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[3] R.L. Bashshur, *The pioneering era of telemedicine* [in:] R.L. Bashshur, G.W. Shannon (ed.), *History of Telemedicine. Evoluation, context and transformation*, Mary Ann Libert, Inc., New Rochelle, NY 2009, p. 134 (132-154).
[4] K.T. Bird, *Teleconsultation: a new health information exchange system. Third Annual Report*, Veterans Administration, Washington DC, 1971.
[5] R.L. Bashshur, *Telemedicine and medical care* [in:] *Telemedicine: Exploration in the Use of Telecommunications in Healthcare,* R.L. Bashshur, P.A. Armstrong, Z.L. Youssef, Springfield, IL, 1975.

behavior in terms of physician and administrator regard for quality of care and data confidentiality.

Initially, the development pace of telemedicine system was extremely slow. In fact, apart from the telephone telemedicine system, one can find only single solutions that would meet the criteria of a telemedicine system. The initial interest in the use of TV systems for the needs of medical data transfer could be observed in 1950s. Apart from K.T.Bird, Cecil Wittson from the Nebrasca Psychiatric Institute, who conducted experiments with the use of TV for psychiatric consultations, was one of the pioneers[6]. The exploration of space contributed to the use of satellite communication for the needs of medical data transmissions – new satellite telemedicine networks were developed for example in Alaska[7] or Australia[8]. The necessity to provide medical support to astronauts in space stations resulted in a deeper interest in the opportunities to diagnose diseases such as skin diseases on the basis of images that were sent remotely. The popularity of telemedicine grew after the earthquake in Armenia in 1988 when a kind of a satellite bridge was arranged by agreement between the Soviet Union and USA to improve the relief for the earthquake victims[9].

As ICT technologies developed, new and more complex systems emerged that enabled sharing patient's data among various users and for various purposes. The leaders in telemedicine development did not only include the USA but also other countries, particularly the ones with colonial traditions such as Great Britain and France which wanted to maintain contacts with their overseas territories. There were also other countries such as Australia or Norway, which – because of geographic reasons or a well-developed fleet - aimed at the application of the available communication technologies for medical purposes.

The original telemedicine projects had a limited range and time of operational activity. Many of them ceased to operate when the financing from central budgets was terminated or the resources allocated in the form of research and development grants were exhausted. Such situation appeared mainly in the 1980s and the early 1990s when the use of telecommunication connections that were offered by operators in particular countries was extremely expensive.

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[6] C.L. Wittson, R. Benschoter, *Two-way Television: Helping the Medical Center Reach Out*, The American Journal of Psychiatry 1972, 1 April 2006, https://ajp.psychiatryonline.org/doi/abs/10.1176/ajp.129.5.624 (accessed: 20 November 2019).

[7] R.L. Bashshur, G.W. Shannon, *Telemedicine comes of age* [in:] R.L. Bashshur, G.W. Shannon (ed.), *History of Telemedicine. Evoluation, context and transformation*, Mary Ann Libert, Inc., New Rochelle, NY 2009, p. 203 (187-235).

[8] N. Brown, *A brief history of telemedicine,* „Telemedicine Information Exchange" 1995, 30 May, No.101.

[9] C.R. Doarn, A.E. Nicogossian, R.C. Merrell, *Applications of telemedicine in the United States space program,* Telemedicine Journal 1998, No. 4(1), pp. 19-30.

The situation changed dramatically with the development of the Internet and the expansion of ICT networks. An increasingly wider perception of telemedicine testifies to the growing technical capacity and application range of telemedicine. The document from 1998 that presented the information strategy of NHS in UK defined telemedicine as *any healthcare-related activity (including diagnosis, treatment, and monitoring) that normally involves a professional and a patient, or one professional and another who are separated in space (and possibly also in time).*[10]

Initially, two main types of telemedicine systems were distinguished: a real-time or synchronous system and an asynchronous system in which it takes some time to send data for consultations and to receive the opinion from the reference center[11]. The first type was based on the transmission of audio and video signals and it required a much wider bandwidth and consequently the access to a more advanced ITC infrastructure and a greater organizational effort so that all stakeholders of a telemedicine session were available at the same time. The asynchronous systems were also referred to as store-and-forward systems and they did not have such significant requirements regarding the transmission band since the data transfer process could be extended in time and consequently the systems could be used in places where the ICT infrastructure was very limited. Obviously, in this type of systems there was no need to make appointments with all stakeholders as the specialists or the centre that received the data did not have to reply immediately to the data sender. Quite soon, apart from the two above systems, telemonitoring systems emerged that enabled the transmission of data obtained in patients' home environment or by patients themselves. The systems could operate both in the synchronous or asynchronous modes depending whether the reply of the monitoring centre after the reception of patient's data was immediate or deferred. For many years, the only example of telemonitoring was the electrocardiographic signal transmission (tele-ecg); it was used to monitor the functioning of pacemeakers and after some time to support patients with life-threatening arrhythmias or episodes of myocardial ischemia[12].

The technological progress in telecommunication, sensor and videoconference technologies resulted in the fact that the tradition division to real-time and *save and send*

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[10] *Information for Health: An information strategy for the modern NHS 1998-2005: a national strategy for local implementation*, NHS Executive, London 1998.
[11] M. Maheu, P. Whitten, A. Allen, *Telecommunication Technologies in Health Care* [in:] M. Maheu, P. Whitten, A. Allen, *E-Health, Telehealth, and Telemedicine. A Guide to Start-Up and Success*, John Wiley & Sons, 2002.
[12] N.M. Hjelm, H.W. Julius, *Centenary of tele-electrocardiography and telephonocardiography,* Journal of Telemedicine and Telecare 2005, No. 11(7), pp. 336-338.

systems was not enough. In the early 2000s, a more complex classification of telemedicine applications was proposed. The taxonomy of B. Tulu, S. Chatterjee and S. Laxminarayan was based on 5 criteria: purpose, application area, environmental setting, communication infrastructure and service delivery options[13]. The application purposes were divided into two main categories: clinical, such as diagnostics, consultations, provision of specialty care, and non-clinical applications related to public health or patient education. The application area referred to medical specialization or other fields where telemedicine application was implemented. Environment settings covered such issues as the surrounding where the participants of the session were placed including the attributes that affected the quality of the information sent or the type of entities that were involved in telemedicine sessions. Communication infrastructure concerned the links used to transmit and receive the data. Finally, service delivery options regarded the issues of synchronous or non-synchronous contacts as well as the type of data that was sent in telemedicine sessions, such as sound, video, text or graphic. Recently, the above divisions seem rather anachronous considering the integration of several functionalities that are available in telemedicine. Nevertheless, the attempts to classify the accessible solutions may be crucial from the point of view of taxpayers in the healthcare system or the institutions that set the standards of telemedicine-based healthcare services.

In 1999, analogously to such terms as e-commerce or e-business, the term e-health (eHealth) appeared. The range of the concept evolved quickly. Initially, it referred simply to on-line medical services but already in 2001 Gunther Eysenbach gave new meaning to the term[14]. G.Eysenbach's definition related the application of ICT systems to public health. However, this meaning was very soon replaced by a wider reference to the use of ICT systems in the context of health issues. Despite further attempts to make a narrower definition of the idea of e-health, the wider meaning of the term was maintained especially that WHO used a definition which seemed to promote such interpretation: *eHealth is the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research*[15].

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[13] B. Tulu, S. Chatterjee, S. Laxminarayan, *A Taxonomy of Telemedicine Efforts with respect to Applications, Infrastructure, Delivery Tools, Type of Setting and Purpose*, Proceedings of the 38th Annual Hawaii International Conference on System Sciences 2005, January, s. 147b.
[14] G. Eysenbach, *What is e-health?*, „Journal of Medical Internet Research" 2001, No. 3(2), e20.
[15] WHO, *58 World Health Assembly*, WHA58.28 eHealth, Ninth Plenary Meeting, 25 May 2005.

It seems that for at least 20 years *eHealth* has become the applicable term both in scientific research and in planning and implementing ICT technologies in healthcare and medicine. The use of the term *eHealth* in scientific publications and strategic documents does not mean that the term *telemedicine* ceased to be applied. Most frequently, it is used to refer to technologies that are applied in medical services offered by doctors and other staff of medical institutions

It cannot be ignored that a widespread use of the term eHealth resulted in misunderstandings and the misuse or even appropriation of the term. At present, it is used both by professionals who deal with the implementation and maintenance of information systems in healthcare entities, innovators who offer new electronic services and also researchers who analyze the use of online health data.

2. From eHealth to Health 2.0

The development of the concept of eHealth involved a transition from separate activities typical for telemedicine that occurred between selected entities, mainly medical ones, to a ubiquitous service environment that may involve various users.

On the whole, two development models of eHealth environment can be distinguished: dispersed and centralized ones. The first one includes subsequent eHealth applications that are developed ad hoc, depending on the needs of various stakeholders of the healthcare system and the requirements of business initiatives. The centralized model assumes a development of an eHealth environment core structure such as a patient identification system or even a system of a digital health register of the population. The core structure may be the basis for subsequent solutions that are either centralized or result from the interests of business entities.

From the point of view of business, eHealth environment supported such basic processes as business-to-business (B2B) and business-to-consumer (B2C) but it also offered new opportunities such as consumer-to-consumer (C2C) or even consumer-to-professional (C2P)[16]. While B2B and B2C suited the traditional business relationships between healthcare service providers and recipients in the first cases and patients (health service consumers) and service providers in the latter, C2C processes reflected a new approach that was offered by the information environment. This was also a symptom of the next development stage in the area

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[16] N. Kordzadeh, J. Warren, *Toward a typology of health 2.0 collaboration platforms and websites*, Health and Technology 2013, No. 3(1), pp. 37-50.

of eHealth, which began to be referred to as Health 2.0. C2C includes processes that are dedicated by patients with particular diseases to other patients with similar problems, e.g. online support groups. The demand for such initiatives was proved by the popularity of such online services operating in USA as patientlikeme.com[17] which enables patients to share their experience or wegohealth.com which promotes patients who are change leaders in the healthcare system[18]. Such initiatives cannot be ignored as the advice to patients with a newly diagnosed disease from people who suffer from similar diseases may be as valuable as the advice from a doctor, especially if they concern non-medical issues and everyday problems of coping with the illness.

Due to the multidimensionality of eHealth environment it is difficult to develop a clear classification of all possible solutions and applications. According to the Authors, with regard to the purposes and functions of public health and healthcare, the main application areas of eHealth systems cover:

- health situation surveillance (infodemology, participative epidemiology, infomonitoring);
- promotion of health and disease prevention (supporting healthy lifestyle, assistance in combating addictions);
- supportive environment created by patients and their relatives;
- monitoring patients and other people (telemonitoring in chronic diseases, tracking persons with cognitive impairments, smart house technologies);
- communication in healthcare between service recipients and providers and among service providers;
- sharing digital health records;
- administrative and support activities for healthcare system stakeholders (online registration, e-Prescription, e-Referral).

Currently, telemedicine is frequently considered an eHealth area that regards contacts with a clinical context. Regarding the classification above, telemedicine activities are visible in several areas such as patient monitoring or the communication between patients and doctors.

The dynamic development of eHealth environment arouses interest of various healthcare system stakeholders including healthcare workers, patients but also decision-makers and

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[17] *Patientslikeme – Our mission,* https://www.patientslikeme.com/about (Accessed: 20 November 2019).
[18] *The Network of Patient Leaders,* https://www.wegohealth.com/ (Accessed: 20 November 2019).

politicians. The expectations concern the improvement of healthcare services, particularly with regard to the continuity of care, the support of shared care and patient's self-reliance.

3. Health 2.0

In 2004, T. O'Reilly described Web 2.0 as *a set of economic, social, and technological trends that collectively form the basis for the next generation of the Internet, a more mature, distinctive medium characterized by user participation, openness, and network effects* [19]. The main feature of the Internet development stage that was referred to as Web 1.0 was a ubiquitous access to information. The evolution of the telecommunications systems from stage Web 1.0 to stage Web 2.0 , which was referred to as the social web, was connected with the appearance of the community of users who are not only the recipients of digital information but also its producers. In order to indicate the role duality of the global web users, the term *prosumers* is used following the concept used in other fields, e.g. in the power generation sector.

The new approach to the role of the Internet users led to a change in the expectations from eHealth. While telemedicine systems and the first eHealth applications assigned a key role to medical and health authorities in the development and provision of e-services, an increasingly greater significance was attached to patients, citizens and society with the development of social media and the decreasing role of traditional communication channels. A significant interest in the application of Web 2.0 in healthcare was reflected by the number of the definitions of Health 2.0 that appeared in various publications. The systematic review published by T.H. Van De Belt et al. shows that at least 46 definitions of the term were proposed before 2010[20]. The simplest ones stated simply that the term refers to the use of Web 2.0 tools in healthcare[21], that it is *content and community*[22] or *the merging of social media into healthcare*[23]. A more complex attempt to define Health 2.0 which was given in a Reuters report is worth presenting[24]: *Health 2.0 is a new concept of health care that employs social software and other web-based tools to promote collaboration between patients, their caregivers, medical professionals, and other*

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[19] T. O'Reilly, *What is Web 2.0?,* http://oreilly.com/web2/archive/what-is-web-20.html (Accessed: 20 November, 2019).
[20] T.H. Van De Belt, L.J. Engelen, S.A. Berben, L. Schoonhoven, *Definition of Health 2.0 and Medicine 2.0: a systematic review*, Journal of Medical Internet Research 2010, No. 12(2), e18.
[21] Ibidem.
[22] J.M. Gorman, M. den Braber, *Semantic Web Sparks Evolution of Health 2.0–A Road Map to Consumer-Centric Healthcare*, Health 2008, No. 2, pp. 1-2.
[23] A. Rampy, *Defining Health 2.0*, SocialButterfly 2008, http://fly4change.wordpress.com/2008/04/30/defining-health-20/ (Accessed: 20 November, 2019).
[24] Reuters, *Boston Becomes a Hotbed for Health 2.0*, 2008.

stakeholders in health care to create a better, more knowledgeable and cost effective environment for better well-being.

Conclusions

The advance in communications technologies was inseparably connected with the attempts to apply them in healthcare. Initially, the replacement of a traditional, direct contact between a doctor and the patient was strongly rejected both by the medical environment and patients themselves. Thus, at first the application of communications technologies in medical for the purpose of medical contacts was a result of a necessity, for example when this was the only possibility to receive professional assistance. Along with the development of information technologies and the increasingly advanced possibilities to store and transfer data, the arguments for the use of telemedicine and then eHealth systems were the result of the desire to enhance healthcare, improve the access to health services and provide continuous and multidisciplinary care. Currently, the application of ICT systems, particularly of the Internet and mobile technologies, is directed towards the provision of a versatile support to patients in their locations. Moreover, there is a change in the perception of the role of patients, who – thanks to the systems that are referred to as Health 2.0 – are not only the recipients of information and services but also offer themselves their support to people facing similar health issues.

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[3] Bashshur R.L., Shannon G.W., *Telemedicine comes of age* [in:] Bashshur R.L., Shannon G.W. (ed.), *History of Telemedicine. Evoluation, Context and Transformation*, Mary Ann Libert, Inc., New Rochelle, NY 2009, p. 203 (187-235).

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[8] Gorman J.M., den Braber M., *Semantic Web Sparks Evolution of Health 2.0–A Road Map to Consumer-Centric Healthcare*, Health 2008, No. 2, pp. 1-2.

[9] Hjelm N.M., Julius H.W., *Centenary of tele-electrocardiography and telephonocardiography,* Journal of Telemedicine and Telecare 2005, No. 11(7), pp. 336-338.

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[13] O'Reilly T., *What is Web 2.0?,* http://oreilly.com/web2/archive/what-is-web-20.html.

[14] *Patientslikeme – Our mission,* https://www.patientslikeme.com/about.

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[19] Tulu B., Chatterjee S., Laxminarayan S., *A Taxonomy of Telemedicine Efforts with respect to Applications, Infrastructure, Delivery Tools, Type of Setting and Purpose*, Proceedings of the 38th Annual Hawaii International Conference on System Sciences 2005, January, p. 147b.

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[21] WHO, *58 World Health Assembly*, WHA58.28 eHealth, Ninth Plenary Meeting, 25 May 2005.

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Abstract

The first definitions of telemedicine come from 1970s but the first attempts to use communication tools in medicine were described at least one hundred years before. As the increasingly better opportunities of data transmission emerged, new and more complex telemedicine systems were developed. The reasons for the development of the first telemedicine systems included the necessity to provide access to medical assistance in sparsely populated

areas, emergency situations or during sea or air travel. Issues concerning the enhancement of medical care, the access to medical data or the possibility to receive specialist consultation started to gain in importance with the development of ICT technologies. Recently, eHealth is the key term to be used in ICT application in healthcare. It refers both to contacts between medical staff and patients, or between medical staff, and the online access of patients, their relatives and all citizens to health data as well as the development of IT systems in medical institutions and any other healthcare entities and the provision of such support activities as online registration or e-prescribing.