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PRACA POGLĄDOWA
REVIEW

Determinants of telemedicine development in health care system

Uwarunkowania rozwoju telemedycyny w systemie ochrony zdrowia

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ABSTRACT

Nowadays, telemedicine is a rapidly developing field of medicine in Poland. The amended Act on the information system in health care, applicable from 2015, should facilitate access to e-health services for patients. The aim of the present study was to review data on the role of ICT solutions in various fields of medicine. The present review of the literature was based on peer-reviewed journal databases (PubMed, Medline, Embase, Google Scholar) and Internet sources. Publications and Internet sources, included in the current review, were published from 2008 to 2016. The development of information technology has a significant impact on the progress of telemedicine. Many countries (including Poland) provide e-health services to its citizens. The results of the study indicate that medical consultation, diagnosis and telecare can be successfully carried out at a distance. The benefits of telemedicine are significant, both to patients, people related to health professionals as well as for the payer.

KEY WORDS
telemedicine, ICT, telecardiology, telecare, occupational medicine, e-monitoring

STRESZCZENIE

Telemedycyna jest formą świadczenia usług medycznych z wykorzystaniem narzędzi telekomunikacyjnych i technologii teleinformatycznych. Obowiązująca od 2015 roku nowelizacja ustawy o systemie informacji w ochronie zdrowia powinna ułatwić pacjentom dostęp do e-usług medycznych. Celem pracy było omówienie roli rozwiązań teleinformatycznych w różnych dziedzinach medycyny. Dokonano przeglądu piśmiennictwa, opierając się na bazach czasopism recenzowanych (PubMed, Medline, Embase, Google Scholar) oraz źródłach internetowych. Dane literaturowe, które włączono do przeglądu, pochodzą z lat 2008–2016. Rozwój technologii informatycznych istotnie wpływa na dynamiczny postęp w zakresie telemedycyny. Coraz więcej państw (w tym Polska) świadczy e-usługi medyczne swoim

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obywatelom. Wyniki badań wskazują, że konsultacje lekarskie, diagnostyka i teleopieka mogą być z powodzeniem prowadzone na odległość. Korzyści wynikające ze stosowania telemedycyny są wymierne zarówno dla pacjentów, osób związanych zawodowo ze służbą zdrowia, jak i płatnika.

SŁOWA KLUCZOWE
telemedycyna, teleinformatyzacja, telekardiologia, teleopieka, medycyna pracy, e-monitoring

INTRODUCTION

According to the European Commission's definition from 2008, telemedicine "is the provision of healthcare services, through use of ICT, in situations where the health professional and the patient are not in the same location" [1].

In some fields of medicine such as pathology, radiology, radiotherapy, cardiology, rehabilitation and occupational health care, direct contact between a doctor and a patient is not always necessary to make a correct diagnosis. Telemedicine enables interactive videoconferencing between medical specialists as well as between a doctor and a patient. It also allows for transmitting static and dynamic images and performing surgeries [2].

The most notable advantages of telemedical services are:

- clinical support
- fast consultation and diagnosis
- assistance of medical specialists, benefiting from their knowledge and experience (it is of particular importance in the case of hospitals far away from big medical centres)
- monitoring the patient's condition
- reducing the cost of medical services
- overcoming geographic barriers (thanks to the latest multimedia technology, videotelephony and the Internet)
- increased opportunity of professional training for doctors and medical staff, especially in remote areas.

Recently, dynamic population ageing has been observed. The number of people aged 60 and over is forecast to surpass one billion by 2015 and the percentage of the elderly will amount to 13.7% of the world's population [3]. In Poland at the end of 2014 the number of people past the productive stage of life surpassed 7 million and constituted 19% of the population [4]. It is estimated that by 2050 the number of people aged 65 and ove will come to one third of the population [5]. The need for such medical services in the mentioned age group will systematically increase. People at the post-productive age are the most common to suffer from chronic diseases and disabilities. Comorbidity and, consequently, polypharmacy are crucial problems, hence individual care of the elderly will be of fundamental importance for years to come. The possibility to use telecommunication and information technologies to provide health care will become essential [6].

Nowadays, the fastest development of telemedicine is observed in highly developed countries, mainly in the USA. Such countries see there the chance of effective health care development. Deutsche Bank's report [7] indicates that the whole European eHealth market is expected to grow by approximately 5% and the telemedical service sector will experience an approximate annual increase of 10% between 2006 and 2020.

The aim of this work was to review the available literature concerning the use of ICT solutions for medicine and the effectiveness of telemedical care in Poland and around the world.

The literature review was based on bibliographic peer-reviewed journal databases (PubMed, Medline, Embase, Google Scholar). The publications and Internet sources included in the review come from the years 2008–2016, with the latest reports prevailing. The following key words were used: telemedicine, ICT, telecardiology, telecare, occupational medicine, occupational diseases, telediagnosis, teleconsultation, telemedical applications, e-monitoring, portable telemedical devices. The work presents information on telemedicine and its role and development, underlining telecare, telecardiology and occupational medicine. A review of services and telemedical programmes available in Poland at the moment was conducted as well.

Development of telemedicine in Poland

For some years now, the European Union has been supporting the implementation of innovative ICT technologies in health care. As indicated by the analysis of legislation recommended by the European Commission, the priorities are: improving access to health care and increasing the efficiency of health centres. In 2004 the European Commission formulated an action plan in order to create a European e-Health Area ('e-Health – making healthcare better for European citizens: An action plan for a European eHealth Area'). Its aim was to implement e-Health technology by the end of 2010. All EU member states were called to develop the national and regional e-Health strategy. The Commission placed crucial importance on: reducing wait time, preventing queues of patients wanting to use health care and minimalizing the occurrence of

mistakes during patient diagnosis. According to the aforementioned plan, one of the aims to be achieved by the end of 2008 was to launch online services such as: teleconsultation, e-prescriptions, telemonitoring, telecare [8].

The prospect of high grants for programmes propagating innovative solutions in health care offers a solid base for development of the whole telemedical market in Poland. One of the examples of initiating the development of telemedicine and facilitating access to highly specialized treatments was the project 'Telemedicine in kujawsko-pomorski region'. In 2005 the Voivodeship Government acquired a 9.3 million zloty grant from the Integrated Regional Operational Programme [9].

On the other hand, the project called 'Telemedicine within the Euroregion Pomerania – Pomerania network' cofunded by the European Regional Development Fund as a part of the Cross-border Cooperation Operational Programme between Germany (Mecklenburg-Vorpommern/Brandenburg) and Poland (West Pomeranian Voivodeship) INTERREG IV A 2007––2013 [10] was launched in the West Pomeranian Voivodeship. Twenty-one German hospitals, eleven Polish hospitals and two universities from Szczecin (West Pomeranian University of Technology and Pomeranian Medical University – Polish coordinator of the project) took part in the project. The motto of the project was 'let data move, not the patients'. That is why the project was aimed to develop a cross-border telemedical network and enable vocational training for Polish and German doctors and hence improve health care for patients in sparsely populated areas. The created telemedical network allows institutions to establish a high level of health care covering fields such as preventive care, diagnosis and therapy, mainly of cancer, but also accidents and cardiovascular diseases [10].

One of the launched projects is called Wielkopolska Center of Telemedicine. It enables medical teleconsultations, medical teleeducation, supporting clinical decisions and expert reporting. The first teleconsultations were in the field of trauma surgery. The platform allows medical professionals to conduct teleconsultations between hospitals in Wielkopolska and specialists from Poznan University of Medical Sciences [11].

In 2014 the 'Baltic Declaration' was signed. Its aim was to increase the use of telemedical solutions in a group of patients with cardiovascular diseases. It was indicated that improvement in diagnostic efficiency, effectiveness of the therapy, care and rehabilitation of cardiologic patients, especially the elderly, is possible [12]. On 27th August, 2015 the President of the Agency for Health Technology Assessment and Tariff System issued a statement on tariffs of guaranteed health care services, including cardiologic and geriatric consultation using telemedical devices, and the possibility of its public funding [13].

Legal determinants of telemedicine development in Poland

Thanks to the development of ICT technologies, telemedicine allows for providing health care services by professional medical staff at a distance in the fields of consultation, medical examinations, diagnosis, treatment and preventive treatment. In October, 2015 an amendment to the bill on the information system in health care was ratified (the bill of 9th October, 2015 on changing the bill on the information system in health care and some other bills) [14]. It allows for providing specific services and pronouncing a patient's condition with the use of ICT solutions by professional medical staff. A doctor is able to start treatment based on data provided by the communication system without physical examination. The new laws entail implementing an e-Health platform (Electronic Platform for Collection, Analysis and Sharing of Digital Medical Records) giving patients access to: e-prescriptions, e-referrals, e-orders and a Patient Internet Account. A new tool making electronic transactions credible called eIDAS comes into effect on 1st July, 2016 (Regulation (EU) No 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC). Electronic data such as texts, audio recordings, visual recordings, audiovisual recordings will be proclaimed electronic documents. The first telemedical programmes supported by the National Health Fund (NHF) are being run right now. The NHF President's regulation no 63/2015/DSOZ from 30th September, 2015 allows for conducting cardiologic and geriatric teleconsultations and their funding. The services are aimed at patients from rural areas and are provided in places designated by NHF. The advantage of such health care services is the use of the latest communication technologies to care for a patient for whom going to distant specialist medical centers is too expensive or sometimes even impossible due to immobilization. The drawback of this programme is low social awareness of the possibility of using such a health care solution, lack of access to ICT technologies (digital exclusion) and too little expenditure on the implementation of telemedical solutions. The safe provision of telemedical services entails great financial investments in implementing acknowledged technologies of data processing and retention, supporting the ICT infrastructure and covering the costs of salaries for specialists maintaining and managing 24-hour monitoring.

Development of geriatric and cardiologic telemedical services

For some years now, research on using the latest ICT solutions for interactive communication between a patient and a doctor has been conducted [15]. That is the reason why some new systems that facilitate the use of medical services for patients, especially the elderly, are emerging. The E-health service for patients allows for online registration, sending electronic prescriptions, sending alerts for the next doctor's appointment, sending reminders for taking medicine, sending test results and information from a doctor and access to medical documentation. Phone consultation with a doctor or a nurse and telemonitoring of basic vital signs is also possible [16]. It is possible to implement home telecare, telecardiology, telediabetology, telepulmonology and telerehabilitation. Home telecare aims at monitoring a patient's behaviour. Fall detectors and motion sensors with alarm applications to call for help are installed at the elderly's place of stay [16,17]. Home telecare also allows for showing a given person's location. When a sick person goes beyond the monitored area, the guardian gets a text message. The 'GPS Monitoring' service is available in Poland. A patient is equipped with a navigation system that provides information about their current location. Thanks to this, the disappearance of people suffering mainly from dementia and Alzheimer's disease is prevented [18]. Since 2013, telemonitoring services have been available and subsidized in Opole, Kluczbork, Bytów and Gdynia [16]. The project TELEOPIEKA was launched in the Society for the Help for People with Alzheimer's Disease in Katowice. It propagates patients' everyday safety and the possibility of a working life for a guardian. The TELEOPIEKA programme offers calling for help, remote medical consultation and diagnosis, prevention, medical care and psychological services [19]. Moreover, TELEREHABILITACJA offers comprehensive cardiorehabilitation in a patient's house using a Cardio Monitor which supervises ECG recording [20]. The Comarch e-Care platform from Cracow allows for monitoring vital signs and maintaining remote contact between a patient and doctor [21]. The Healthman system offers an initial telediagnosis of a patient and the Matsushita application allows for the monitoring of many vital signs such as pulse, heart rate, blood pressure, body temperature and blood glucose level [22].

Tele-ekg® digital EHO type devices are used in telecardiology. They register and store ECG results or other tests (oxygen saturation, pulse, blood pressure and body weight) and send them to a doctor through available media. They can function as an event-holder device or be used in cardiologic rehabilitation at home. A device in the event-holder mode continuously registers the patient's heart beat and registers the recording in the device memory which works in a loop. In the case of the occurrence of pain, recording can be activated. It contains an ECG section before the activation (a reverse buffer) and a section after activation that is moments before the pain, during as well as after the pain [23]. The PocketECG system offers arrhythmia diagnosis lasting many weeks and heart beat monitoring. The results are sent directly to a doctor or a monitoring center [24].

A significant increase in patients after the implantation of cardiac pacemakers, implantable cardioverter defibrillators (ICD) and resynchronization devices with a cardioverter defibrillator function (CRT-D) is observed every year. Periodic control of the implanted devices is necessary for patients. Data transmission from the device memory to a server through an ICT network allows for its immediate control by an authorized person. Currently, various information systems provide telemonitoring [25,26]. 'Clouds' enable the storage of patients' medical documentation. Data services have to meet the requirements of the Health Insurance Portability and Accountability Act [27]. In December 2015, the Cardiology Clinic of the Medical University of Warsaw implemented, for the first time in Poland, a 24 hour system for the monitoring of patients with implanted heart electrotherapy devices [28]. The Silesian Centre for Heart Diseases in Zabrze implemented cardiologic videoconsultations for patients (Lync/Skype technology). A cardiologist takes part in the patient's examination and at the same time can consult their condition with a GP or other specialist who is in direct contact with the patient [29].

Telemedical solutions in field of occupational medicine

ICT systems can also be used for the diagnosis, treatment and preventive treatment of occupational diseases. There are several reports concerning the role of teledermatology in the preventive treatment of work-related skin diseases. Baumeister et al. [30] conducted a cross-sectional study to evaluate teledermatological test results covering the detection of hand skin changes among 100 employees engaged in metal processing (exposed to cutting fluids) and compared it to a conventional study. The authors observed that skin assessment during a teledermatologic examination was more critical compared to a conventional study and turned out to be accurate enough to detect early symptoms of workers' eczema.

65 women with neck and shoulder pains emerging during their work took part in a Swedish study concerning pain assessment and work ability assessment with the use of a biofeedback teleservice [31]. 33 women were included in a telemedical study and 32 women – the control group – took part in a conventional study. The study forms were filled in three

times: before the intervention, in the first period of the observation and three months after the end of the intervention. An improvement in pain relief and the ability to work was observed in both groups, without significant differences. Significant time saving of the conducted teleconsultations compared to conventional care has been observed (41 minutes/teleconsultation). Moreover, it has been acknowledged that employees can do teleconsultations and muscle relaxation training while performing their jobs. It is highly significant for employees as well as the employer [31].
The usefulness of a portable system for ECG recording (iECG – Internet-enabled ECG recording system) was analyzed among 24 Japanese workers residing abroad likely to come down with a circulatory system disease [32]. The studied patients were given instructions to send ECG records obtained through iECG using their PCs from the countries of their current residence. Analysis of the ECG results was presented to a study participant and an OM specialist via e-mail. 504 ECG recordings were obtained during the study. No new cases of circulatory system diseases were observed. However, some heart beat irregularities were registered, namely: irregularities in the ST segment and T wave along with a block in a left branch of the bundle of His, bradycardia and an atrial fibrillation. 68% of the studied patients were satisfied with such a form of heart beat monitoring [32].

Latest ICT technologies

Numerous innovative technological solutions that influence the development of telemedicine exist in the healthcare market, such as: a portable ultrasound machine for home use, a pocket stethoscope that enables ECG recording, GPS tracker armbands facilitating care of the elderly, remote monitoring of CTG recording during pregnancy and sleep monitoring devices for people suffering from sleep disorders. Chai et al. conducted a study using Google Glass – a device functioning as a portable recorder with a screen and a speaker. It has the ability to recognize the oral commands of the user. These cyber glasses were used for remote toxicological consultations and it was stated that they can be an effective tool for drug overdose diagnosis and therapy. Teleconsultation was successful in 89% of the cases [33]. A Coded Hemodynamic Imaging portable device allows for measuring a patient's pulse in a few places without skin contact. The device can work remotely and monitor people with burns or inform about the danger of an embolism [34]. The Braster Tester device is constructed using matrices covered with a liquid-crystal mixture that records thermal changes occurring in breasts and allows for early detection of breast cancer. Cancer cells induce hyperthermic areas, which is used as a thermal marker for cancer. The device is compatible with an application installed on a smartphone or tablet and the thermographic images are sent to a healthcare center and analyzed. Evaluation of the device's effectiveness in diagnostics and differentiating breast pathologies was conducted in a group of 736 patients with diagnosed breast cancer in comparison to conventional diagnostic methods. The study showed that the Braster Tester is effective and useful in the diagnostic process of mammary gland pathologies [35]. CellScope is a combination of an otoscope with a video otoscope. The device gives a view of the external ear canal and the tympanic membrane and displays it on a smartphone application. The data can be sent for medical consultation. The study conducted in a group of 51 pediatric patients with otolaryngologic issues showed that CellScope is easy to use and it improves diagnosis in comparison to conventional methods [36].

Evaluation of telemedicine in diagnostics and therapy

Many studies conducted around the world confirm the effectiveness of telemedicine in diagnostics and therapy. Gratzer et al. stated that the application of internet-delivered cognitive-behavioural therapy is as efficient as pharmacotherapy in the case of mild and moderate depression [37]. A questionnaire survey on a group of patients, doctors and teleconsulting coordinators that used the Missouri Telehealth Network system in 62 Missouri counties (the USA) show that 83% of patients are satisfied with such a service. 86% of doctors and 67% of coordinators were also satisfied [38]. The rehabilitation of a group of 205 patients with an implanted knee endoprosthesis involving a stationary and a video conferencing method showed that both techniques produced similar results for the patients [39]. Zhao et al. [40] on the other hand, confirmed the high effectiveness of telemedicine in the diagnosis of pathologic tissue changes. Specialists from the Pathology Clinic (University of Pittsburgh Medical Center) in the USA held remote consultations with the Pathology Clinic (KingMed Diagnostics, Guangzhou, Guangdong) in China. Correct diagnosis was given in 82% of difficult cases thanks to this cooperation [40].

CONCLUSION

The benefits of telemedicine applications are substantial for the patients, medical staff as well as the payer. Considerable improvement in the quality and accessibility of medical services, reducing funds for patient treatments and for health care centres which use telemedicine are observed. It was estimated that telecardiology care in Germany reduces the annual treatment cost by 1200 euros for one patient, which indicates

20% savings per annum [7]. The application of telemedicine also allows for saving time which is intended for the journey to a health care center in case of traditional patient-doctor contact.

However, apart from the unquestionable benefits of using telemedicine in patient care, one cannot forget about the drawbacks of such a solution. The problems are: the medical environment not being open to such contact with a patient, gathering massive amounts of data and problems with their quick interpretation and their safety, the responsibility for the decisions made during teleconsultation. The necessity of acquiring special equipment and/or software can also be a limitation.

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