Research Article

The Sustainable e-Health System Development in COVID 19 Pandemic - The Theoretical Studies of Knowledge Management Systems and Practical Polish Healthcare Experience

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Abstract

The paper describes the sustainable e-health system concerning the theoretical studies and practical Polish healthcare experience. The aim of the paper is to describe the theoretical issues of sustainable development in e-health, and to show practical issues of information and communication technologies (ICTs) as the knowledge management factor in healthcare system. The paper presents the role of ICT such as artificial intelligence and knowledge management systems for sustainable healthcare system development. The research study is based on the critical review of literature from the last 5 years, and the examples of Polish implementation of e-health system due to COVID-19 pandemic. The first two chapters of the paper present the idea of sustainable development and characterize technologies supporting sustainable development in Polish e-health system. The second part characterizes the knowledge management methods and their role in sustainable development support. The examples of e-health systems showed the concept of e-health system development in Poland. In the third part, the research study is performed based on the research methodology. Finally, the results and conclusion describe the usage of research methods and discuss the results of critical literature review for the concept of sustainable e-health system development.

Keywords: Sustainable development, ICT, knowledge management, e-health

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Introduction

Sustainable development is one of the challenges to reach in the 21st century. With the help of IT technologies and knowledge management methods, enterprises are ready to transform their economy, waste management and other business processes and provide it in more sustainable way for the benefit of themselves and other market participants. Especially these particular needs are visible in the healthcare system hit by the ongoing COVID-19 outbreak.

The market of services related to a healthy lifestyle is developing rapidly, which is favored by digital technologies (applications and mobile devices). New businesses are emerging as a result of the convergence between wireless technologies and devices used in healthcare and between healthcare and social care.
On the one hand, patient empowerment and digital skills in e-health are essential for its successful implementation. On the other hand, e-health makes it easier for patients to heal and for healthy people to use preventive measures. However, a significant barrier is the lack of awareness of the opportunities and challenges that e-health presents for users (citizens, patients, medical workers and social workers).

According to the definition of the European Commission, e-health is the use of modern information and telecommunications technologies in order to meet the needs of citizens, patients, health care workers, healthcare providers, as well as the legislative authorities (Dymyt, 2020). However, according to the definition of the World Health Organization, the sustainable e-health system is a term used to describe the combined use of information technology and electronic communication in the health sector or the use in the health sector of digital data transmitted, stored and downloaded electronically for clinical, educational and administrative purposes, both locally and remotely. Additionally, mobile health (m-health) is a developing e-health segment that includes medical and public health practices supported by mobile devices. These are in particular: the use of mobile telecommunications devices for health, health support services, information services and mobile health applications. M-health is a rapidly growing field: approximately 100,000 m-health applications are now available on multiple platforms in the global marketplace. M-health has the potential to play a role in transforming healthcare towards increasing its quality and efficiency. M-health helps to empower patients: they can manage their health more actively, live more independently thanks to remote monitoring solutions. M-health can also support healthcare professionals in treating patients more effectively through mobile applications that tie the patient to a healthy lifestyle. However, research shows only 2% of health apps are used in United States hospitals due to lack of end-user engagement and poor development not concentrated on patients' needs (Wali, Keshavjee and Demers, 2018).

The article has been divided into some chapters. The theoretical background is showing the sustainable development in e-health with characteristics of some aspect of knowledge management in e-health in Poland, and the analysis shows the overview of sustainability of Polish e-health systems development. The research was focused on research questions: How important is the ICT factor for e-health sustainability system described in literature? How to build the sustainable e-health system concerning the theoretical studies and practical

Polish healthcare experience. The research results were briefly summarized and discussed at the end of the article.

Theoretical background

Sustainable development in e-health

Sustainability and sustainable development are terms meaning respectively:

- a process for creating sustainable, successful environments that promote wellbeing, by understanding what people need from the places where they live and work (Colnar, Dimovski and Bogataj, 2019).
- development that meets the needs of the present without compromising the ability of future generations to meet their own needs (*What is sustainability?*, no date).

The meaning of sustainability is ambiguous and not defined precisely, it can differ between branches, visions and approaches. Many people equate sustainability with ecology, nature preservation and resources management. The United Nations established the Millennium Development Goals to achieve by the year 2015, which were not met fully but helped to improve quality of life for millions of people around the world. Nowadays, Sustainable Development Goals (SDGs) – more ambitious and affecting more areas of life UN project is underway. One of SDGs to achieve in 2030 is to "ensure healthy lives and promote well-being for all at all ages" (Dawa, Narayan and Narain, 2021; United Nations, no date).

A conclusion follows from the above definitions:

- sustainability is related with well-being and meeting the particular needs,
- sustainability is related with further generation care,
- sustainability is related with local environment.

Sustainable development in literature is mostly described in four or five dimensions (Ziemba, 2020):

- ecological sustainability,
- economic sustainability,
- cultural sustainability,
- social sustainability,
- technological sustainability – sometimes it's mentioned as one of the sustainability dimensions (Fuchs, 2006), in other research studies, it is considered as an enabler of the mentioned above (Ziemba, 2020, 2021).

Health and well-being according to literature are considered as examples of social sustainability (Ziemba, 2021), however efficient and responsible use of resources (economic sustainability) by hospitals and institutions is also an important factor. According to Yeboah, to develop sustainable healthcare system, all sociocultural, political, economic and environmental factors are required like also efficient planning, smart use of resources and partnership between healthcare system stakeholders (Yeboah, 2016).

The healthcare performance concept has evolved since 1980's from simple budgetary control through multidimensional performance, society perspective, up to sustainability, resilience and building societal value (Vainieri *et al.*, 2020).

In the healthcare sector, sustainability and use of telehealth is more visible in poor, rural countries, e.g. Rwanda, where the number of qualified healthcare

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personnel per 1000 people is very low (about 0,064) (*Rwanda and the Dreamers of Digital Health in Africa: Wakanda Is Real*, 2018; *Telemedicine in Rwanda: The Future of Health*, 2019). According to Babyl company – largest AI-based healthcare system provider, registered application users are over 2 million (*Babyl – Rwanda's Digital Healthcare Provider*, no date).

In Poland, it has been observed a gradual digitization of healthcare system along with its centralization. Central registers are created and developed for the needs of many different aspects of healthcare system functioning e.g., patient registration, drug safety monitoring, medical professional education, etc. There exists research in Poland confirming the positive impact of the use of technology in increasing the effectiveness of therapy i.e. the use of SMS messages as a reminder and for educational purposes has positive impact on patient therapeutic adherence, knowledge about disease and change in harmful health habits (Wizner *et al.*, 2009).

The research potential of the use of e-health technologies such as mobile applications, wearables, telemedicine and patient information portals remains high. The challenges to develop e-health systems are mostly related with concerns about data safety, privacy like also the quality and usefulness of data (Wali, Keshavjee and Demers, 2018; Dymyt, 2020).

ICT as the knowledge management factor in healthcare system

In healthcare system, knowledge and information flow are key elements in smooth and efficient functioning. Knowledge management methods and practices are currently used in healthcare. The development of information systems for the management of health knowledge concerns systems for managing knowledge about the patient, health knowledge, knowledge about health care units, knowledge about drugs, etc. Health information systems and services based on ICT technologies, including SOA (Service Oriented Architecture), web solutions, websites, information portals, ubiquitous computer systems, including mobile network technologies (RFID, QR) (Sołtysik-Piorunkiewicz, 2014) are successfully used by the information society. On the one hand, the emphasis is primarily on the development of HIS (Health Information System), EHR (Electronic Health Record), EMR (Electronic Medical Record), CPOE (Computerized Physician Order Entry), ETP (Electronic Transfer of Prescriptions), PHR (Personal Health Record), and on the other hand, platforms are developed to ensure the distribution of medical knowledge contributing to the improvement of the quality of life in the area of health in terms of self-diagnosis, self-treatment, fitness of the elderly and others.

The sustainability in Polish e-health system – an overview

Polish examples of patient knowledge management systems include eWUŚ, ZIP, e-prescription, EKUZ, OSOZ, while among the systems dedicated to self-treatment or self-diagnosis, there is a large number of information portals and websites that allow for knowledge management, e.g. the implementation of diffusion processes knowledge about health among patients of the same disease entity, as well as discussion forums, thematic blogs and others.

This section presents research results of analysis on the current use of digital technologies supporting sustainable development in Polish healthcare system. Since the second half of 2010's, healthcare system in Poland is undergoing a digital transformation. Table 1 presents some of the technologies that are currently mandatory to use, a

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short description about them and dates of   their implementation.

Table 1: Digital technologies currently used in Polish healthcare system

Technology/ system name	Description	Implementation date *(*Ustawa z dnia 28 kwietnia 2011 r. o systemie informacji w ochronie zdrowia*, 2021)*
Electronic insurance card	Electronic card system used to proof eligibility to insurance and registration in clinic.	2001[1]
eWUŚ	Electronic beneficiary verification system.	01.01.2013
eZLA	Electronic sick-leaves system.	01.12.2018
e-prescription	Electronic prescription system. Part of P1 system.	08.01.2020
P1	Electronic platform for gathering, analysis and sharing digital resources about medical events *(System P1, no date).*	31.12.2019
P4	Integrated healthcare statistics and drug safety monitoring system.	31.12.2019
IKP (Internetowe Konto Pacjenta)	Network Patient Account – an electronic medical information system for patients. Also available as mobile application (mojeIKP)*(mojeIKP na komórkę lub tablet | Pacjent, 2022)*	26.09.2018
mObywatel	Mobile application designed to provide digital identity, replaces various documents.	6.12.2021

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[1] Implemented only in Silesian Voivodeship

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First examples of healthcare digitalization process in Poland were already observed at the beginning of the 21st century, where insurance verification process was automated with the use of digital card developed by Silesian Regional Health Insurance Fund, and after transformation and centralization of regional insurance funds, cards were issued by the Silesian Department of National Health Fund. The plan to extend the use of card to other country regions failed (Sołtysik-Piorunkiewicz, 2014). With the development of electronic beneficiary verification system (pl. eWUŚ), electronic cards began to lose their importance and were definitely withdrawn in 2021 (Chruścińska-Dragan, 2021).

Beneficiary verification system was implemented in 2013, and just like the electronic card, it confirms the patient's rights to use healthcare services financed from public funds (e-WUŚ, no date).

Electronic platform for sick-leaves (pl. eZLA) is a system coordinated by Social Insurance Institution (ZUS) as a part of PUE ZUS platform (Platform of Electronic Services). Doctors since 1st January 2016 are available to issue electronic medical certificate via PUE platform; the certificate is automatically transferred to employer by Płatnik system and to patient (employee) after creating profile on PUE platform (Zakład Ubezpieczeń Społecznych, no date). Since 1st December 2018, it's mandatory and only electronic leaves are acceptable (Strona główna - ZUS, no date).

Electronic prescription system (pl. e-recepta) is obligatory since 8th January 2020; before this date, it exists in parallel with paper prescriptions. According to research, doctors do not believe that e-prescriptions are more efficient or that they make their work easier (Wrzosek, Zimmermann and Balwicki, 2020). Although they provide patients access to prescription via electronic patient portal,

improve therapeutic adherence due to better readiness than paper prescription and make fraud more difficult.

P1 project is an electronic platform of public services which includes several applications and services including e-prescription, Internet patient account, medical data gathering system, pharmacy systems (System P1, no date).

P4 system is a project including statistical system in healthcare, monitoring the education of healthcare professionals, integrated medicines trade monitoring system, emergency monitoring system and healthcare resources evidence system (Systemy informatyczne w ochronie zdrowia w ramach Projektu P4, 2015).

During COVID-19 pandemic, many e-health systems were developed directly or indirectly related to managing the pandemic's crisis, beginning from analytical systems used to track the coronavirus spread and statistics related to infections and casualties, up to monitoring quarantine and vaccination programs. The Polish example of these systems can be found in IKP system (Internetowe Konto Pacjenta – Internet Patient Account), which is a system for patients to monitor all of their medical data including visits since 2008, medications, prescriptions, COVID-19 certificates (vaccination, negative test result and convalescent status) like also notifications about quarantine obligation and referrals for vaccination or additional medical procedures.

The mObywatel (mCitizen) application formerly known as mTożsamość (mIdentity)(mObywatel (dawniej mTożsamość), no date) is an application that stores many identity documents in digital form e.g. ID card, driving license with information about vehicle registration certificate and obligatory insurance, school/student ID and also

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European COVID certificate, e-prescription. mObywatel requires authentication via trusted profile (pl. Profil Zaufany) – an authentication and verification method implemented in polish administration (*Strona główna - Profil zaufany*, no date).

The implementation of these systems was beneficial for sustainable development due to, among other reasons:

- Elimination of paper document workflow and associated with it errors and inaccuracies.

- Enabling patients to access the medical services via web.
- Better control of administration processes in healthcare, better fraud detection and possibilities to monitor public health more effectively due to obligatory data.

Material and Methods

The research methodology is based on critical literature review in selected journals with management in healthcare or technologies in healthcare profile. Methodology schema is presented in Fig 1.
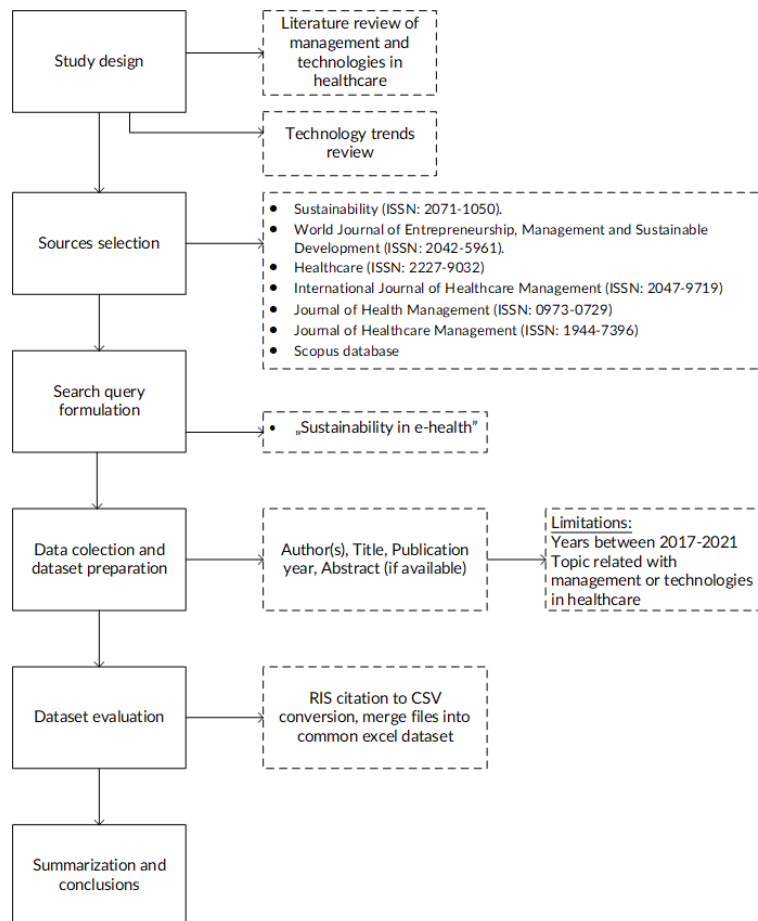

Fig 1. Research methodology

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The research study was conducted based on research questions concerning the information and communication technology usage as a knowledge management factor for building the concept of sustainable e-health system. The research study was divided into some research steps. During the study design, the following research questions were asked: How important is the artificial intelligence factor for e-health sustainability system described in literature? Is it possible to build a sustainable e-health system concerning the Polish healthcare experience?

The source collection was based on available journals datasets. Selected journals are presented as follows:

1. General – related with sustainability/sustainable development:

- Sustainability by MDPI AG (ISSN: 2071-1050).

- World Journal of Entrepreneurship, Management and Sustainable Development by

Emerald Publishing (ISSN: 2042-5961).

2. Related with management in healthcare:

- Healthcare by MDPI AG (ISSN: 2227-9032).

- International Journal of Healthcare Management by Taylor & Francis Group (ISSN: 2047-9719).

- Journal of Health Management by SAGE Publishing (ISSN: 0973-0729).

- Journal of Healthcare Management by the American College of Healthcare Executives (ISSN: 1944-7396).

In addition to journals' research, a Scopus database was also searched with the same query. Research findings are presented in Table 2.

Table 2: Research findings

Journal/database	Papers found	Papers accepted	Papers rejected
Sustainability	78	15	63
World Journal of Entrepreneurship, Management and Sustainable Development	2	1	1
Healthcare	2	1	1
International Journal of Healthcare Management	250	64	186
Journal of Health Management	85	28	57
Journal of Healthcare Management	24	7	17
Scopus	45	29	16

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Two articles found in Scopus database were duplicated from Sustainability journal search and one article was duplicated in International Journal of Healthcare Management.
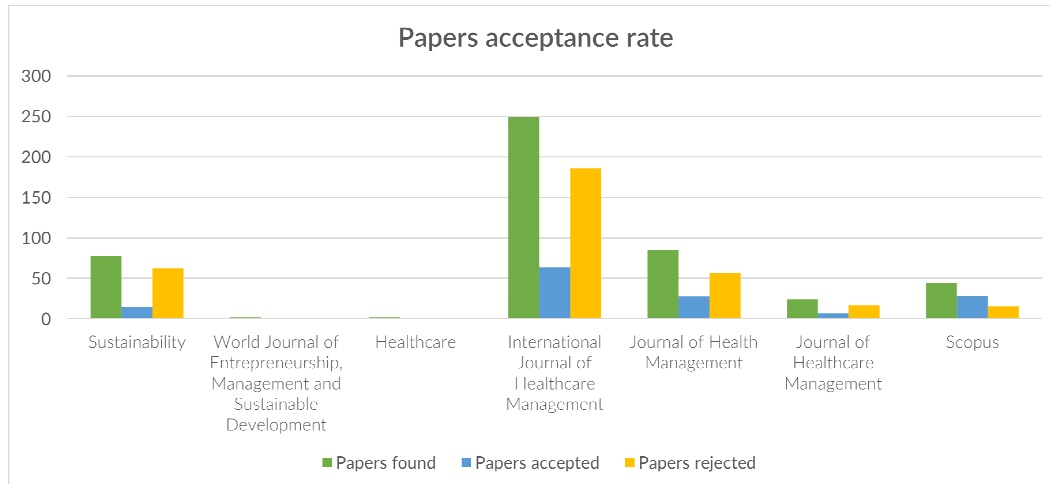

Fig 2. Paper acceptance by journal/ database

Acceptance criteria were based on title and abstract; only papers related with sustainability/ sustainable development and healthcare were accepted to further review. Articles that describe the use of ICTs were preferred. Papers related only with medical topics or only with sustainability, environment were rejected. The largest number of results was found in International Journal of Healthcare Management (250 papers found, 64 related to the topic).

Results and discussion

Artificial intelligence (AI) is one of the developing trends in e-health, successfully used in many countries. It is possible to achieve one of the sustainable development goals, even with poor access to healthcare professionals, but with technology development supported by governmental financing and society education, i.e., Rwanda.
In Poland, digital transformation of healthcare system started at the beginning of the 21st century and speeded up in the second half of 2010's. Currently still ongoing process focuses on patients' access to digital services and centralization of medical events' datasets in national repositories.

Javed et al. propose a concept of integrated social entrepreneurship with ICT technologies to achieve sustainable social order such as sanitation, access to water and healthcare (Javed *et al.*, 2021). In their concept, electronic social enterprise consists of such factors as social value creation, ICT and ICT-based innovations and environmental complexity. The adoption of ICTs leads organizations to develop in sustainable way and helps to achieve competitive advantage (Javed *et al.*, 2021). According to Auener et al., ongoing COVID-19 pandemic creates possibilities to reform healthcare system in more sustainable way e.g. better coordination in hospitalization and purchasing, limitation of low-value care overtreatment, reducing bureaucracy in healthcare (Auener *et al.*, 2020). Bokolo notes positive impact of telemedicine adoption in healthcare due to limited contact of ill patients with

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healthy ones and minimizing the risk of infection (Bokolo, 2021) which is especially suitable for pandemics but also can be used during seasonal influenza. The mentioned article also points to the possibility to integrate telemedicine systems with national emergency systems (Bokolo, 2021) which can be also used e.g. in elderly patients' care. However, we should be aware that telemedicine is not always a possible solution and it's not without drawbacks.

Wollesen et al. propose a multidimensional approach for promoting health in German companies to reduce musculoskeletal diseases which are the most common causes for sick-leaves in European companies (Wollesen *et al.*, 2016). Although the article does not mention the ICT use, it points to goal-orientation and individualization of the program, which offer the opportunity for use e.g., mobile technologies related with AI to better suit every individual need and apply this approach to larger scale.

According to Gottielb et al., healthcare system should be based on patient care strategies (social risk informed care, social risk targeted care) and community health strategies (financial resources, partnership) to reduce social barriers to high-quality care access (Gottlieb *et al.*, 2019). Botti & Monda presented an example of e-health system use in context of sustainable value co-creation (Botti and Monda, 2020). Faggini et al. provide similar research about using digital platforms to achieve sustainability in healthcare by creating patterns leading to achieve enduring improvement of health outcomes (Faggini *et al.*, 2018).

Based on the literature on the subject and the analysis of previous implementations of knowledge management systems using ICT technologies, the sustainable e-health systems need to take into account the concept of building a holistic knowledge management system: Internet database

systems (Web-based system), mobile applications, early warning systems, intelligent decision support systems, BI systems and artificial intelligence systems.

Conclusions

Based on literature, the information and communication technologies like AI will most strongly develop towards supporting sustainable development. Artificial Intelligence related with medical robotics has currently received high attention (Yoon and Lee, 2019). The use of AI in healthcare can provide more patient-centered and tailored health services for each individual. It also can lead to cost reduction and waste management in healthcare facilities. The limitation of the research project is the selective selection of journals and the review nature of literature research.

Further authors' work will concentrate on development and ICT use in healthcare system in Poland with comparison to other countries and also the barriers of ICT implementation in healthcare system. The purpose of the article was to show the importance of modern information and communication technology tools (interactive communication channels, software agent-oriented technologies, etc.) in sustainable e-health system project. Research presents the assessing ICT tools in the sustainable knowledge management systems describing the literature published during the last five years. The article begins with theoretical considerations on sustainability in e-health systems, and then we discussed the development and evolution of ICT technologies and their application to knowledge management in the context of sustainability of e-health in Poland. The paper is focusing on the knowledge management system in the context of sustainable e-health.

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Acknowledgment

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