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Łukasz Gabig

Digital Transformation in Public and Non-Public Medical Diagnostic Entities in Poland: An Overview of Solutions

Abstract

Objective: Digitisation and digitalisation are among the key developments in contemporary health care, including medical diagnostics, shaping the way diagnostic entities operate in both the public and private sectors. This article focuses on the theoretical analysis of digitisation processes in diagnostic units, with a particular focus on Information and Communications Technologies (ICTs) management and their impact on the efficiency of medical services.

Research Design & Methods: The conducted analysis is based on a critical review of the literature on e-health, health IT management, and the digital transformation of medical diagnostics in the public and private sectors. Key areas of investigation include electronic medical records, telemedicine systems, artificial intelligence applications, and the Internet of Things within diagnostic facilities.

Findings: The review indicates that implementing electronic medical records, telemedicine systems, artificial intelligence, and the Internet of Things significantly increases staff productivity and operational efficiency in diagnostic facilities. At the same time, considerable challenges were identified, such as staff resistance to change, the need to ensure the interoperability of systems, and guaranteeing a high level of patient data security.

Implications / Recommendations: The conclusions of the analysis highlight the key role of effective IT management and institutional support in fully exploiting the potential of digitisation and digitalisation. Suggestions for recommendations for policymakers and health care managers were also formulated, targeting the strengthening of public–private partnerships (PPPs) as a strategic tool to support further digitisation of medical diagnostics.

Contribution / Value Added: This work synthesises diverse strands of literature into a coherent theoretical framework for ICT management in medical diagnostics.

Keywords: medical diagnostics, public and non-public sector, public–private partnership, IT governance, digital transformation, e-health

JEL classification: I18, L86, O33, M15, L15, L33.

Łukasz Gabig – "TK MEDICA" Sp. z o.o., ul. Balewskiego 1, 83-200 Starogard Gdański, Poland; e-mail: lg@tkmedica.pl; ORCID: 0009-0007-6150-8237.

Introduction

Digital technology (DT) is one of the key trends encompassing all of modern health care. However, this analysis pays particular attention to its impact on medical diagnostics as one of the many aspects of this process. The aim of the transformation in this area is not only to increase the efficiency of diagnostic procedures, but also to minimise the risk of medical errors and optimise the management of diagnostic facilities in both the public and private sectors, thereby improving the quality and availability of medical services. In an era of increasing demographic and epidemiological challenges (ageing populations, chronic diseases, global health threats such as the COVID-19 pandemic) (WHO, 2021), digitisation is becoming an essential tool to ensure high quality and accessible health care. This process is changing the way diagnoses are made and managed – from electronic medical records, to diagnostic image archiving and transmission systems, to remote consultations and telemedicine. The introduction of information technology (Information Technology, IT) (OECD, 2020), comprising systems and tools for processing, storing, and transmitting information – such as computer hardware, software, databases, or networks – is the basis for the digitisation and digitalisation of health care. However, the implementation of more advanced digital technologies such as Artificial Intelligence (AI) (Topol, 2019), Big Data (BD) analytics (Batko, 2016), the Internet of Things (IoT), Cloud Computing (CC) (Moumtzoglou & Kastania, 2014), and Augmented Reality (AR) (Eckert et al., 2019) is also crucial. Their integration aims to streamline the work of medical staff, increase the accuracy and speed of diagnosis, and reduce the operational costs of health care providers.

Diagnostic entities – which include, among others, medical laboratories, diagnostic imaging facilities, endoscopy laboratories, or companies providing outpatient diagnostic services – face a particular opportunity and challenge in the face of advances in digitisation and digitalisation. On the one hand, modern IT systems and devices enable the automation of analyses, the integration of test results into patient records, and remote specialist consultations, which can significantly improve the quality and efficiency of services. On the other hand, the implementation of these solutions requires significant financial outlays, appropriate staff preparation, and the adaptation of organisational processes. In the public sector (e.g. diagnostics in public hospitals), implementations often depend on government strategies and public funds, while the non-public sector (private laboratories and clinics) is also driven by market factors and competitiveness. It is important to understand whether and how these two segments differ in terms of the pace and manner of digitisation.

A review of existing studies suggests that digitisation brings tangible benefits to medical diagnostic providers, affecting both work efficiency and the quality of provided services. For example, Gjellebæk and colleagues (2020) show that the implementation of new digital technologies in health care contributes to increased staff productivity, improved efficiency in the operation of medical entities, and reduced operational costs. Similar trends can be observed in strictly diagnostic medical facilities, where digital systems improve the processing of test results, reduce waiting times for diagnosis, and enable more precise analysis of clinical data. At the same time, as noted by Eden and colleagues (2018), by the end of the past decade, nearly 75% of US hospitals were already using electronic health record systems, supported by government financial incentive programmes. However, despite widespread use, the effectiveness of these systems did not always meet expectations due to difficulties in use and resistance from some staff. For diagnostic facilities, similar barriers may include the integration of laboratory systems into the hospital

infrastructure, the need for data standardisation, or the challenges of interoperability between different digital platforms. These examples highlight the complexity of the digitalisation process; the mere availability of technology does not guarantee success if there is a lack of effective change management, adequate user training, and adaptation of the organisation's operating mechanisms to the new tools.

The main objective of this article is to provide a structured review and synthesis of the literature on digitisation and digitalisation in public and non-public diagnostic entities. The focus is on three key aspects: (1) the scope and directions of digitisation and digitalisation in medical diagnostics (which technologies are being implemented and for what purpose); (2) the importance of IT governance in the digital transformation of health care; and (3) the impact of technology use on the efficiency and quality of diagnostic services, with a focus on strengthening Public–Private Partnerships (PPPs) as a strategic tool to support further digitisation of medical diagnostics. The article is theoretical in nature, i.e. based on the existing research and the state of knowledge, the main trends and research gaps are identified. The following sections, respectively, present a review of the literature on the subject, a description of the research methodology used, the results of the analysis with a discussion of the key insights, and, finally, conclusions, implications, and suggestions for further directions of study. Thus, the thesis provides a basis for formulating proposals for practical recommendations for health care managers and for identifying areas requiring further research.

Literature review

Digitisation in medical diagnostics. The term 'digitalisation' in medical diagnosis refers to the conversion of analogue medical data into digital format, while 'digitalisation' is about the adoption and use of information and communication technologies to transform diagnostic processes. The literature highlights that digital technologies have the potential to revolutionise diagnostics through automation, data integration, and improved communication between medical staff (Eysenbach, 2001; Topol, 2016). The most commonly described digital solutions in medical diagnostics include:

Electronic health records (EDM/EHR) – systems for storing and sharing patient data in digital form, replacing traditional paper records. Research indicates that the implementation of EDM can improve the continuity of care and patient safety, subject to appropriate integration with workflow and user acceptance. For example, Eden and colleagues (2018) indicated that the implementation of e-health systems changes clinical practices, but that their effectiveness may be limited by the ergonomics of the systems and the excessive information burden on staff.

Diagnostic information includes Laboratory Information Systems (LIS) in analytical laboratories and Picture Archiving and Communication System (PACS) in diagnostic imaging. They enable the digital collection, archiving, and rapid sharing of test results, which significantly reduces diagnostic time and improves the availability of information. According to Marques and Ferreira (2020), the development of such systems has been the cornerstone of digital transformation in health, paving the way for advanced data analytics and the application of artificial intelligence in diagnostics.

Telemedicine and remote diagnostics entails the use of ICTs for remote consultations and diagnostic tests. In diagnostics, specialist tele-consultations such as teleradiology (remote evaluation of imaging studies) or telepathology (analysis of microscopic slides) are of particular importance.

The COVID-19 pandemic significantly accelerated the implementation of telemedicine, leading to a sharp increase in remote consultations and the development of telemedicine platforms. As Baudier and colleagues (2021) point out, the pandemic acted as a catalyst for telemedicine deployments in the public and private sectors, removing some of the previous organisational and regulatory barriers.

Artificial intelligence and machine learning involve data analysis techniques that support the diagnostic process by automatically interpreting test results. An example is the application of deep learning to the analysis of radiological images or histopathological images in digital pathology. Bera and colleagues (2019) indicate that AI tools can increase the accuracy of diagnosis and improve the detection of cancerous lesions, providing important support for pathologists. Integrating AI with diagnostic systems enables the processing of huge clinical datasets, making it possible to detect symptoms earlier and initiate a treatment faster. However, making full use of AI requires high quality datasets and user confidence in algorithmic recommendations (Bera et al., 2019).

The Internet of Things and telemedicine devices involves a network of interconnected sensors and devices that monitor patient parameters in real time, sending data to analytical systems. In diagnostics, examples of the IoT could be smart laboratory analysers, automatically reporting test results, or remote patient monitoring devices (e.g. ECG holsters sending a signal to the doctor). Digitalisation in this area enables more proactive health care, based on continuous monitoring of patients' conditions and early detection of abnormalities, which – according to Moumtzoglou and Kastania (2014) – fits in the trend of personalised and preventive medicine.

IT management in medical diagnostics. The introduction of the above technologies requires effective IT management in medical diagnostic organisations' diagnostics. The literature emphasises that digital transformation involves not only the implementation of new software or hardware, but, above all, a change in processes and organisational culture. Management – its vision, competence, and ability to lead the organisation through the change process – plays a key role here. Gjellebæk and colleagues (2020), when analysing the management challenges of future digitisation and digitalisation, pointed to, among other things, the need to develop the digital skills of staff, adapt organisational structures, and ensure the interoperability of IT systems between different care units. The lack of interoperability and data standardisation can inhibit the full use of e-health – if hospital, laboratory, and clinic systems cannot communicate, then the flow of information is disrupted. It is, therefore, important to establish standards (e.g. HL7, DICOM) and integrate systems at the regional and national levels.

Effective IT management in public and private medical diagnostic facilities also includes aspects of information security and patient privacy. With increasing digitisation and digitalisation, the amount of sensitive medical data collected and transmitted electronically is growing, exposing organisations to cyber security incidents. A review of research indicates that data protection and compliance concerns (e.g. the GDPR in the EU) are a significant barrier to implementing new technologies in medicine. IT governance must therefore consider security policies, data protection training, and business continuity planning for IT systems. Various models and theoretical frameworks supporting IT governance in health care are emerging in the literature. Agarwal and colleagues (2010), in their classic study on the state of digital transformation in health care, pointed out that effective use of technology requires parallel development of competencies, changes in clinical processes, and stakeholder engagement at all levels of organisation. These authors emphasised that leadership in the area of medical IT should combine technological expertise

with an understanding of the specifics of health services to bridge the gap between the 'IT world' and medical staff (physicians, diagnosticians). Furthermore, the literature provides evidence that the nature of the ownership of facilities can influence the pace and manner of the implementation of digitisation and digitalisation. Public facilities often face challenges related to limited budgets and the need to comply with government regulations, whereas private diagnostic units may have more freedom to invest in modern IT systems. Institutional government support and appropriate public policies can stimulate digital transformation – examples include funding programmes for EDM systems (such as the US Meaningful Use programme) (Centers for Medicare & Medicaid Services, 2021) or legislative initiatives allowing reimbursement for telemedicine services, which encourages both public and private health care providers to invest in modern technologies (Centers for Medicare & Medicaid Services, 2020).

The impact of technology on the efficiency of medical diagnostic services. One of the main arguments for digital transformation is that it improves the efficiency and quality of medical diagnostic services. The scientific literature provides numerous examples supporting this claim. Research by Gjellebæk and colleagues (2020) has shown that the digital transformation of health care services leads to operational improvements – both at the micro (e.g. reduction in the time taken to perform and describe a diagnostic test) and at the macro level (better utilisation of resources on a facility-wide basis). The implementation of integrated IT systems eliminates the duplication of activities, reduces waiting times for information, and minimises the risk of errors resulting from manual data entry. For example, following the implementation of a comprehensive IT system in a hospital (including diagnostic, laboratory, and hospital modules), doctors can obtain test results and make clinical decisions more quickly, which will result in a quicker beginning of an appropriate treatment. In quantitative terms, efficiency can be measured by, among other things, the number of tests performed per unit time, a reduction in the average length of stay of a patient, or a reduction in operating costs – and many case studies document improvements in these indicators after digitisation and digitalisation (Ayat et al., 2017). At the same time, some studies show that the effects of digital transformation are not always unequivocally positive or may only become apparent over a longer time horizon. Gopal and colleagues (2019) note that the health sector as a whole is characterised by lower levels of digital innovation compared to industries such as finance or retail, which translates into relatively slower productivity growth in health care . In other words, despite heavy technological investment, health care suffers from the so-called productivity paradox; inputs do not always immediately result in commensurate improvements in performance. The reasons for this phenomenon are manifold: from the aforementioned user resistance and learning curve of new systems, to the additional administrative burden of digital bureaucracy, to the mismatch between organisational processes and the capabilities of technology. Boonstra and Broekhuis (2010), in a review of barriers to the implementation of electronic health records in hospitals, pointed out that human factors (such as acceptance of change, staff commitment) and organisational factors (work culture, leadership, training) are as important as the technical aspects of the systems in determining the success of a project.

Summarising the literature review, there is a broad consensus that digitisation and digitalisation constitute an inevitable and desirable direction for diagnostic entities, both public and private, potentially improving the quality of diagnostics, improving information and resource management, and meeting increasing patient demands for the speed and accessibility of medical services. However, successful implementation and use of the technology requires the consideration of management and human factors. The differences between the public and non-public sectors in terms of digitisation

and digitalisation are not exhaustively explored: individual case studies suggest that private facilities may be quicker to adopt innovations in pursuit of competitive advantage, while public entities often benefit from a wider range of system support (e.g. central e-health platforms). In the following sections of the article, building on the identified sources, the results of the analysis focused on comparing the experiences and challenges of digital transformation in the two sectors will be presented as well as the implications of these findings will be discussed.

Research methodology

The present study is a theoretical research based on the method of a systematic literature review. In order to ensure the reliability and comprehensiveness of the analysis, an approach was followed in line with Webster and Watson (2002), who recommend a conceptually centric review of scientific literature. This means that key concepts related to digitisation and digitalisation in diagnostics (e.g. e-health, health IT systems, digital transformation, efficiency, etc.) were taken as a starting point, and then key publications and research findings were identified around these.

The research procedure involved several steps. First, a literature search was conducted in leading scientific databases (including the Web of Science, Scopus, PubMed, IEEE Xplore, SpringerLink, and ScienceDirect) as well as a review of reports and industry documents on the digitisation and digitalisation of health care. Key word combinations in Polish and English corresponding to the topic of the paper were used, e.g. digital health, IT, diagnostics digitalisation, health IT governance, and medical diagnostics efficiency. Particular attention was paid to publications from the last 10–15 years, as this period is characterised by intensive development of e-health technologies. However, older works (e.g. on technology adoption models or earlier attempts at health IT) were also included to put more recent reports in context. Second, among the identified sources, those that directly relate to digitalisation in the context of diagnostic services or more general issues of IT management and efficiency in health care were selected. The criterion for inclusion was content relevance (whether the source contributes relevant information on at least one of the three aspects studied: technology in diagnostics, IT management, efficiency) and quality/credibility (peer-reviewed articles, publications indexed in the WoS/Scopus, and official reports of health sector institutions were preferred). In total, about thirty sources were selected for in-depth analysis, including research articles, review articles, and selected case studies. Third, a content analysis of the collected publications was carried out, identifying recurring themes, results, and conclusions. In doing so, a taxonomy in line with the aim of the study was used: findings on (a) implemented digital technologies in diagnostics and their characteristics, (b) organisational and management factors influencing these implementations, and (c) the measured or expected impact of digitalisation on efficiency and service quality. This structure of the analysis allowed the state-of-the-art knowledge to be synthesised as presented in the previous section (Literature review).

Finally, the results of the review have been collated comparatively for the public and non-public sectors where this was possible on the basis of the available data. It should be noted that relatively little empirical work explicitly compares the two sectors; therefore, the analysis is exploratory and indicates some trends rather than hard generalisations. The literature review was supplemented by consulting selected statistics (e.g. adoption rates of EHR systems in different countries, investment in health IT in the public vs. private sector) to ground the discussion in numerical realities where possible.

The theoretical methodology adopted in this article allows for a holistic view of the problem of digitisation and digitalisation in medical diagnosis. Although no in-house field research or interviews were conducted, a thorough analysis of the scholarly output provides a solid basis for conclusions and recommendations. This approach is in line with the nature of the *Journal of Public Governance*, which publishes both empirical and theoretical papers with significant contributions to public governance and health policy.

Survey results and discussion

The analysis of the literature has identified a number of important insights into digital transformation in diagnostic entities, distinguishing between the public and non-public sectors, and identifying the managerial implications of this phenomenon. The main results are presented below, together with an interpretation.

1. A widespread implementation of basic digital systems. In both the public and private sectors, there is a high level of the implementation of basic digitisation systems for information processes, such as electronic patient records and digital examination archives. In many developed countries, the adoption of EDM/EHR systems in hospitals has reached a level of near saturation; for example, in the USA, about 75% of hospitals had at least a basic EHR system already in 2015. Eden and colleagues (2018) found that around three-quarters of US hospitals were actively using electronic patient records, which was a result of, among other things, the federal IT subsidy programme (HITECH/Meaningful Use). In Europe, the pace of digitisation and digitalisation has been more variable, but in general, public health systems (e.g. the NHS in the UK or Scandinavian systems) have developed an extensive e-health infrastructure. In Poland, basic elements of health care digitisation, such as electronic prescriptions or referrals, have been introduced at the national level in recent years, which has forced the computerisation of diagnostic entities as well. The non-public sector, on the other hand, often implemented systems more quickly in those areas where they brought a competitive advantage; e.g. private diagnostic laboratories have been offering doctors and patients online access to test results since the 2000s, which has become a standard of customer service. However, the results of the review indicate that simply having an IT system does not equate to using it effectively. In many institutions (especially public ones), there is a phenomenon of an incomplete use of the systems' functionality or the parallel maintenance of parts of the records traditionally, which reduces the potential benefits of digital transformation (Boonstra & Broekhuis, 2010). This leads to the conclusion that further actions are needed to improve the integration and usability of the existing systems, e.g. user training, a simplification of interfaces, or better adaptation of software to clinical practice.

2. The unevenness of the encroachment of advanced diagnostic technologies. More advanced forms of digitalisation, such as the use of artificial intelligence, expert systems, or the IoT, are not yet uniformly present in all diagnostic entities. The literature indicates that large entities (often public teaching hospitals or private diagnostic networks) are more likely to participate in AI pilots and implementations, e.g. in radiology or pathology. In contrast, smaller units, especially private ones with limited resources, may remain at an earlier stage of digitalisation, focusing on core systems. For example, a study by Ayat and colleagues (2017), conducted in Iranian hospitals, which compared the IT maturity (i.e. according to the EMRAM model) of five public and three private hospitals showed that all of them were only at the initial levels of maturity (EMRAM levels I and II), and even the private hospitals appeared to be less advanced than the public

hospitals in terms of using advanced functionalities of hospital systems. The authors explained this by the lack of health policy pressure and the financial constraints of the private sector in that region. In contrast, in the so-called developed countries, private players are often at the forefront of implementing innovations: for example, large networks of private diagnostic imaging centres invest in state-of-the-art AI solutions to offer faster and more accurate analyses (which becomes a marketing element). In this case, it can be concluded that there is a need for further comparative research between sectors to determine which factors (funding, regulation, size, or organisational ownership) most influence the rate of the adoption of advanced technologies in diagnostics. Governments and policymakers can support the bridging of these gaps, e.g. through innovation grants for smaller players or the creation of public–private partnerships (PPPs) to jointly implement costly technologies.

3. The benefits of digitisation and digitalisation – improved efficiency and quality. The results of the literature analysis confirm the numerous benefits of digitising diagnostic processes. Among the most commonly reported are: reduction in the time taken to perform examinations and issue results, reduction in errors (e.g. sample identification errors due to automation), increase in the number of patients served without compromising quality, and even improvement in health outcomes due to faster diagnosis. For example, the implementation of a tele-consultation system in a radiology laboratory can enable 24/7 description of examinations (radiologists can remotely describe night examinations, which was previously difficult) so that patients in the ER can receive a diagnosis faster. Similarly, the integration of laboratory data with a clinical alert system can prevent critical results from being missed; the system will automatically alert the physician to a result indicating a life-threatening condition. Kraus and colleagues (2021), performing a meta-analysis of the state of research on digital transformation in health, conclude that, in general, digital technologies contribute to increased process efficiency and improved communication in health care, although the exact measure of benefit depends on the specific context and success metrics used in research. In the context of public vs non-public diagnostic entities, it can be speculated that public entities – due to their often larger scale – may achieve greater absolute savings (economies of scale), while private ones emphasise the quality of patient service as an element of advantage (e.g. quick online access to results, SMS notifications), which translates into patient experience as a quality category. In both cases, however, operational efficiency improves if digitalisation is well planned. Organisations should therefore measure the effectiveness of their services before and after IT implementations to capture tangible benefits and quickly identify areas for further optimisation. Sharing best practices (so-called digitalisation benchmarking) between public and private entities can accelerate learning for the sector as a whole.

4. Challenges and barriers – human factors, interoperability, security. Despite the described benefits, the research review highlights a number of challenges that often inhibit the full exploitation of the potential of digitalisation. Firstly, a phenomenon often noted is resistance from staff and stakeholders (Boonstra & Broekhuis, 2010). Doctors and diagnosticians fear that the new systems will increase their computer time at the expense of patient time, or that algorithms will limit their decision-making autonomy. Such attitudes may lead to minimal use of the system (e.g. treating the EDM only as an imposed bureaucratic obligation). It is, therefore, important to involve end users at the design and implementation stage of systems, as well as robust training and technical support. Secondly, interoperability issues are still serious: many systems from different vendors are sometimes incompatible with each other, forcing manual work (e.g. repeatedly entering the same data into different applications) (WHO, 2023). Standardisation and central platforms for information

exchange (such as the P1 platform in Poland for e-prescriptions and e-referrals) (Grabiec, 2022) partly solve this problem, but internally the integration of modules can be technically and financially challenging. Thirdly, data security and cyber threats, such as incidents of ransomware attacks on hospitals (e.g. the 2020 attack on Düsseldorf hospitals), have shown that IT carries the risk of disrupting business continuity (European Union Agency for Cybersecurity, 2023). Diagnostic entities have to invest in security, backups, and contingency plans, which is an additional burden. Finally, legal and regulatory aspects can slow down deployments; for example, procedures for approving AI-enabled medical devices for clinical use are time-consuming, and ambiguities about liability for algorithm error can discourage the use of such tools. The public sector often acts more cautiously due to stronger legal strictures and the need for uniform standards, while the private sector tends to be more flexible, although also subject to regulation. It is fair to conclude that soft (human, organisational) barriers are just as important as hard (technological) ones and require equally careful consideration. Successful digitalisation requires a changed management strategy, continuous improvement of systems, and close collaboration between technology providers and health care providers (Libura et al., 2023; OECD, 2023).

5. The role of public policy and partnerships. This analysis shows that national public programmes and investments have a huge impact on the pace and direction of digitisation and digitalisation in diagnostics. In countries where the government has taken an active role (e.g. by funding infrastructure, establishing interoperability frameworks, educational campaigns), digital transformation has spread to a wider range of actors, including those that are smaller or less well-resourced. For example, Finland and Estonia have established national health data repositories that are used by both public and private facilities; this has forced all players to comply with the standards and enabled a seamless flow of information between sectors. Another example is Denmark, which has launched a unified e-health platform (Sundhed.dk), integrating access to diagnostic results, prescriptions, and health data for all citizens. This has significantly increased the efficiency of communication and collaboration between the private and public sectors. Similarly, South Korea has implemented a comprehensive health care digitalisation programme, implementing a national electronic medical records system covering both public hospitals and private clinics, resulting in a marked increase in the quality of health care services and data accessibility. Public–private partnerships (PPPs) are an interesting model used for large infrastructure projects, e.g. the construction of medical data processing centres or the implementation of telemedicine in rural areas. The case described by Sood and colleagues (2007) was in India, where private technology companies, in collaboration with the government, deployed telemedicine services in remote regions; this study showed that public support (e.g. subsidies) for private initiatives can significantly accelerate the adoption of telemedicine and benefit communities that the technology would otherwise reach much later. Similarly, in Brazil, the 'Telessaúde Brasil Redes' project uses PPP partnerships to implement telemedicine services that increase the availability of diagnostics and specialised consultations in areas with low population or poor medical infrastructure. In Australia, on the other hand, the federal government has invested in public-private partnerships in the creation of a national telehealth network (Australian Digital Health Agency), resulting in an extensive digital infrastructure serving residents from both large metropolitan areas and remote rural areas. In general, where public interest meets private sector innovation, synergies can be developed. In contrast, rivalry or lack of coordination between sectors can lead to a fragmented system (e.g. many incompatible solutions used by different actors). As a result, it is worth concluding that governments should act as a catalyst and coordinator of digitalisation, ensuring

a balance between standardisation and innovation. The creation of platforms for the exchange of experiences between public and non-public diagnostic entities is recommended, as well as continued investment in infrastructure and e-health research.

To summarise this discussion section, digital transformation in medical diagnostics appears to be a multidimensional process. On the one hand, there is the rapid development of technology and growing expectations of its impact on improving health care, and on the other hand, there are the specific institutional and human realities that determine the pace and effectiveness of these changes. The results of the review confirm that technology in itself is not a panacea if it is not accompanied by appropriate leadership, an organisational culture open to innovation, and a coherent operating strategy. This applies to both public and private entities, although the context of the two sectors is sometimes different. The next and final section of the article presents the overall conclusions of the analysis as well as practical recommendations and directions for further research.

Conclusions

The theoretical analysis of digitisation and digitalisation in public and non-public diagnostic entities allows the following conclusions and recommendations to be made:

1. Digital transformation as a prerequisite for modernising diagnostics. For both the public and private sector, the implementation of modern digital technologies is key to ensuring high quality and efficient diagnostic services. Electronic documentation, telemedicine systems, data integration, and the use of AI have ceased to be optional enhancements and are becoming the standard of operation. Organisations that fail to keep up with digitalisation risk reducing their competitiveness (in the private sector) or the quality of care (in the public sector). **Suggested recommendation:** health care decision-makers should treat investment in IT on a par with investment in medical equipment or infrastructure, i.e. as a strategic element of health system development.

2. Improving change management competencies and handling modern technology. Technology will not work without people who are able and willing to use it. The success of digital transformation in diagnostics depends on the acceptance and commitment of medical staff and management. It is advisable for diagnostic facilities to develop the digital competences of their staff (training in the use of systems, basics of data analysis, cybersecurity) and to have an internal dialogue about concerns and expectations regarding new tools. **Suggested recommendation:** introducing formal change management programmes for IT implementations (e.g. appointing implementation leaders/advisers from among staff, piloting systems, collecting feedback and taking it into account when adapting the system) will greatly increase the chances of success.

3. Cross-sectoral collaboration and standardisation. Digital health care inherently crosses the boundaries of single entities; the patient traverses the pathway from primary care, to diagnosis, to treatment, often linking public and private providers. Therefore, system interoperability and information-sharing are fundamental to effective diagnostics. Standardised data standards and communication protocols are beneficial to all stakeholders. **Suggested recommendation:** regulators and industry organisations should continue to develop medical data exchange standards and enforce their use in practice (e.g. certification of systems for compliance with interoperability requirements). In addition, it is worth promoting PPP projects in which the public and private sectors jointly create digital infrastructure by sharing costs and knowledge.

4. Performance evaluation and continuous improvement. Implementing an IT system is not a one-off act, but the start of a process of continuous improvement. Facilities should monitor key performance indicators (KPIs) related to diagnostics – such as turnaround time, the number of patients served, operating costs per unit of service, patient satisfaction – to measure the impact of digitalisation. Where the effects are insufficient, the causes should be analysed (whether the problem is with the technology or its use) and adjustments made. **Suggested recommendation:** a culture of data-driven decision-making (data-driven management) should be developed in organisations. In this way, digitalisation itself also becomes a tool for better management; it provides data that can be used to optimise processes.

The results of this analysis provide public administrations with valuable guidance for health policy, highlighting that investment in the digitalisation of health care brings real societal benefits, such as more efficient diagnosis and, ultimately, better treatment outcomes. However, in order for these benefits to materialise, health policy must include support for soft factors: digital education of human resources, the creation of a legal framework conducive to telemedicine, as well as adequate funding for IT infrastructure (especially for entities that cannot sustain such investments on their own). It is worth continuing programmes such as regional e-health platforms, integrating hospitals, laboratories and clinics into a single information ecosystem.

It should be stressed that the nature of this work as a literature review entails certain limitations. The analysis is based on available publications, which means that in areas where empirical studies are lacking, the synthesis made above may also not provide complete answers. For example, direct comparisons of digitalisation efficiency in the public and private sectors are relatively rare, so some of the conclusions are hypothetical or based on a limited number of cases. Furthermore, the rapid development of technologies means that the literature in this area is rapidly becoming outdated. Solutions considered innovative today, such as the use of artificial intelligence in diagnostics, may become standard in a few years' time, while new technologies, such as the use of blockchain in medical records, will only begin to gain ground. Despite these limitations, the article provides a useful summary of the current state of knowledge, providing a basis for further research and analysis in the digital transformation of medical diagnostics.

Based on the analysis, several key areas for further research were identified. Firstly, comparative studies that take into account sectoral differences are needed, e.g. an analysis of diagnostic efficiency in public and private facilities before and after the implementation of specific technologies. This type of research would verify hypotheses regarding the impact of ownership and financing on the success of digitalisation, as well as identify which factors determine the effectiveness of implementing technological innovations in different organisational models. Secondly, the dynamic development of artificial intelligence in diagnostics requires both clinical research to verify the effectiveness and safety of AI algorithms and organisational research to analyse the impact of these technologies on the professional roles of diagnosticians, the key competencies of the future, and changes in decision-making processes. Thirdly, the economic aspects of digitalisation remain an important area requiring in-depth analysis. A full estimation of the costs and benefits (i.e. Cost-Benefit Analysis) of different diagnostic technologies in different institutional contexts would provide decision-makers with robust data to support investment decisions. Finally, it would be useful to include the perspective of patients in the context of the digitalisation of diagnostics, examining their satisfaction levels, their trust in remote services, and the impact of these changes on patient experience and patient outcomes. These analyses could help to better tailor digital systems to the needs of end users, increasing their acceptance and the effectiveness of implementations.

In summary, digital transformation in medical diagnostic entities is a process with great potential to improve health care. However, for this potential to be fully realised, a holistic approach combining technology, management, and health policy is required. It is hoped that the analysis presented here will contribute to a better understanding of the challenges and opportunities associated with the process as well as inspire further research and practical action, both in the area of medical diagnostics and e-health more broadly.

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