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Review

DIGITAL-BASED SYSTEM AS A TOOL FOR IMPROVING HEALTHCARE COORDINATION - A PERSPECTIVE STUDY

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ABSTRACT

Implementing IT systems for managing patient data, facilitating information exchange among physicians, professionals, and patients, and monitoring treatment progress emerges as a solution with the potential to enhance the quality of care and patient outcomes. This approach holds promise in contributing to a healthcare system that is more efficient and effective. The utilization of these systems can bring about transformative improvements in healthcare delivery. We present the "CORE system", designed as a care coordination tool for primary care settings. The system acts as both a care coordinator and a healthcare professional assistant. Its key features include communication and calendar functions, identification of patients eligible for specific diagnostic pathways, secure sharing and storage of patient medical records, seamless integration with personal vital signs monitors, identification of patients at risk of chronic disease, and analysis of population data for epidemiological reporting. The proposed solution aims to significantly improve the quality of care, patient outcomes, and overall healthcare system efficiency.

KEYWORDS: integrated healthcare, digital solution for healthcare, medical care coordination system.

1. Introduction

Integrated care is a coordinated, comprehensive approach to healthcare that integrates services across levels and types to provide efficient, effective, and patient-centered care, especially for people with complex health conditions. The aim is to improve outcomes in three main dimensions: clinical outcomes, satisfaction, and cost-effectiveness [1].

Primary integrated care involves coordinating care as a primary care provider as the first point of contact in the health system and managing and facilitating access to specialists and other health services. It emphasizes holistic care, addressing the medical, psychological, and social aspects of health. Primary care professionals work with various health and social service providers to ensure comprehensive care. They focus on preventive care to maintain and improve health and prevent illness. Data integration is essential to share patient information across care providers for informed decision-making.

An example of integrated primary care is the Pilot Programme for Coordinated Primary Care (POZ Plus) in Poland, which aimed to implement a coordinated care model at the primary care level. The program aimed to improve the quality of medical services provided at the primary care level. From July 2018 to September 2021, the pilot study explored the feasibility of providing coordinated patient care at the primary care level (POZ), emphasizing broader, more comprehensive, and faster access to healthcare services, including specialist care. One of the main issues raised by health professionals after the pilot was the immaturity of the primary care information system. This aspect was rated the worst in the ex-post analysis. Only 47% of facilities had access to electronic health data, such as laboratory results from external facilities [2]. This is particularly worrying as the role of integrated electronic systems is crucial in integrated primary care. Primary care providers often coordinate care across multiple specialists and services. Electronic systems help track patient progress, manage treatments, ensure consistency of care, and enable more efficient communication between providers. Integrating electronic systems thus improves the quality of care, improves patient outcomes, and contributes to a more efficient and effective healthcare system.

Therefore, this paper aims to summarize the available evidence on the role and effectiveness of digital systems in integrated primary care and to provide insights and perspectives for the further development of such systems.

2. Digital solutions and concerns

Many countries around the world have taken steps to introduce integrated healthcare. Countries follow no single pattern in implementing this in their system. Each does it in its own way, considering the society's customs and the country's conditions. In most countries, the need for integrated healthcare for people with chronic diseases increases as the population ages. This demand requires a fundamental shift in healthcare systems towards more integrated service delivery models.

In China, the World Health Organization, the World Bank, and the Chinese government proposed a multi-level healthcare system based on an integrated, person-centered care model. The pilot implementation was carried out in 2015-2017 in the Luohu district of Shenzhen. In September 2017, China's Ministry of Health introduced the integrated healthcare model nationwide. Before the introduction of integrated healthcare, hospitals, and community health clinics used two different electronic information systems, and providers could only view patient records in their systems. With the pilot study in Luohu, a new computer application called Healthy Luohu was developed and is now available to all healthcare workers. Patients can also access their medical records online [3].

For many years, New Zealand's healthcare system provided fragmented and poorly coordinated services to users. A persistent policy goal in New Zealand was to reduce fragmentation and achieve integrated care. Partial funding of general practice services and continued increases in user fees have created a significant barrier to access to health services for New Zealand residents. Following the introduction of integrated healthcare, primary care organizations decreased from approximately 80 in 2010 to 36 in July 2011 [4]. New Zealand has not introduced a standardized patient management and record exchange system. In light of observed problems with the coordination of healthcare in New Zealand, they need to take action to improve the exchange of information between health facilities. It is also necessary to clearly define responsibility for various aspects of care and establish effective communication procedures. Striving for consistency in care plans and eliminating confusion when changing providers is critical to improving the quality of healthcare services in New Zealand. Implementing solutions that will facilitate the automatic updating of patient records and enhance information exchange may significantly improve healthcare processes in this country [5].

Critical factors such as data security, ethical considerations, and cost-effectiveness play pivotal roles in developing new programs within the healthcare system. Protecting sensitive information, addressing ethical concerns, and ensuring these endeavors' efficiency and cost-effectiveness are paramount in designing robust healthcare solutions.

A fundamental obstacle for today's healthcare management systems is the secure storage and transfer of data [6]. The healthcare sector is an attractive target for cybercrime because it is a lucrative repository of valuable data, and its defenses are often vulnerable. Cybersecurity breaches include the theft of health-related information, ransomware attacks on hospitals, and the potential for attacks on implanted medical devices. Such breaches not only undermine patient confidence but also have the potential to debilitate healthcare systems and pose a threat to human life [7]. In this context, it is worth mentioning health-related applications and the studies carried out on data security. A study published by Alfawzan et al. [8] evaluated applications related to women's mobile health. After analyzing the 23 most popular applications, concerning results were obtained. Each application allowed behavioral tracking, with 61% permitting location tracking. Out of the 23 applications, only 16 (70%) displayed a privacy policy, 12 (52%) sought user consent, and 1 (4%) utilized a pseudo-consent.

Furthermore, three of the applications acquired data before securing consent. Most apps (20/23, 87%) shared user data with external parties, and information on data sharing was unavailable for the remaining 13% (3/23) of apps. Among the 23 applications, merely 13 (57%) provided users with details regarding data security.

However, there are already widely available and extensively utilized software systems that effectively prevent the theft of personal data with high precision. This presents promising prospects for the future; as highlighted in an article by Sreejith & Senthil [9], there exist readily available and extensively applied software systems that effectively thwart the unauthorized access of personal information with exceptional precision. This sets the stage for promising future developments. For example, an in-depth performance evaluation indicates that leveraging Word2Vec features in conjunction with VTFS feature selection and SMOTE resampling, processed through the bootstrapped random forest classifier, yields optimal results. This approach demonstrates exceptional accuracy at 98.86%. These findings underscore its applicability for ensuring robust security in interoperable e-healthcare databases.

Cost-effectiveness is also an essential factor when considering software solutions to ensure security. This aspect was discussed in a publication of Zeleke et al. [10]. A total of 3817 papers were initially identified. The synthesis revealed that electronic data collection systems showed superior data quality and faster processing. Despite implementation challenges such as technical difficulties and security concerns, field data collectors found electronic systems feasible and preferable. Only two studies linked cost and data quality outcomes to discuss the cost-effectiveness of electronic data collection. Noteworthy advantages of electronic systems included onsite data error prevention, rapid data submission, and user-friendly devices. In conclusion, the studies demonstrated the superiority of electronic data collection regarding data quality and efficiency [8]. Unfortunately, there is still a scarcity of publications providing a clear assessment of cost-effectiveness.

It is also essential to analyze the ethical aspect of utilizing medical software in data collection. The most concerning information is presented in the publication by Elizabeth J. Layman in The Health Care Manager, who states that a lack of trust in health data security may lead patients to withhold sensitive information [9]. However, ensuring adequate measures to enhance security can mitigate this concern.

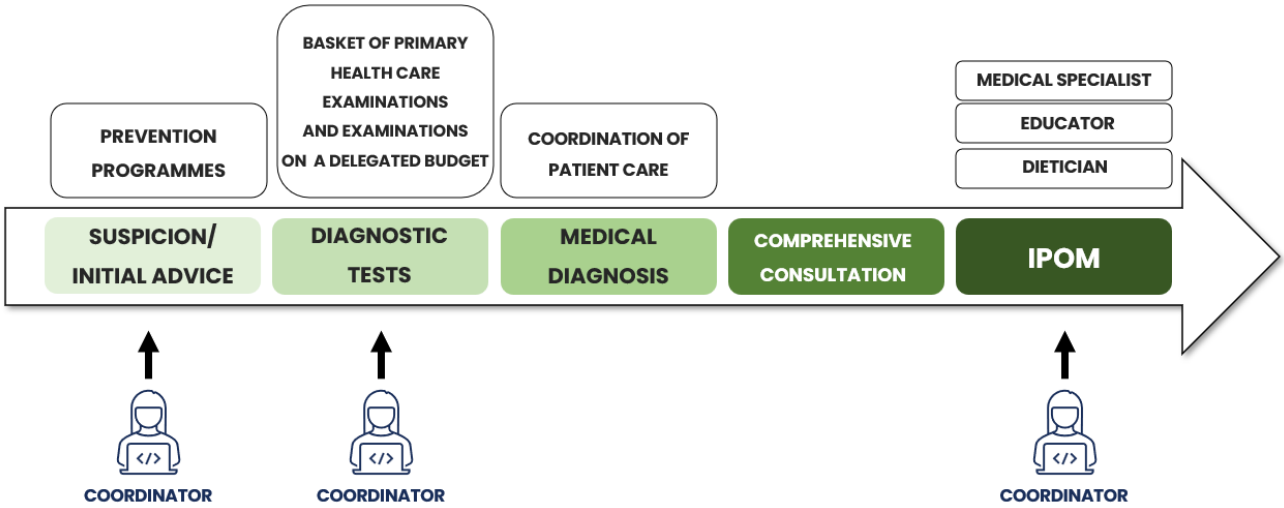

Fig 1. Flow chart for coordinated care. Adapted from (11).

3. Perspective

Today's era of robust development of artificial intelligence-based solutions for healthcare systems promises the development of new tools. The Polish healthcare system introduced a new service, coordinated care, at the end of 2022. Implementing artificial intelligence (AI) can potentially increase the efficiency of this new care model. In this work, we provide a perspective for an AI-based system that would respond to the problems faced by coordinated care delivery.

Coordinated care in primary care (pl. Opieka Koordynowana w POZ) is a dedicated service for managing the most common chronic diseases with your general practitioner (GP). The GP can order tests for patients previously reserved for a specialist. Treatment is based on an Individual Medical Plan (IPOM) and includes tests and consultations between the GP and other specialists.

In medically justified situations, the GP may also order a consultation with a dietician and a specialist in diabetology, endocrinology, cardiology, pulmonology, or allergology. The service covers chronic diseases in the following areas: cardiology, pulmonology, endocrinology, nephrology, and diabetology [10]

A patient potentially suitable for inclusion in a particular diagnostic pathway within coordinated care is ordered to undergo diagnostic tests. After the diagnosis is made, the IPOM is constructed. The coordinator is a staff member (medical or non-medical) who oversees the administrative aspect of the whole process. Their tasks include promoting prevention by actively encouraging patients to undergo screening, making patient appointments and scheduling specialist consultations, organizing follow-up examinations, confirming examinations and reminding patients of them, and communicating other requirements of the individual medical care plan and monitoring its implementation [12].

A pilot study preceded the introduction of the service into the system. Based on the pilot report, problems were identified [13]. The most important of these are shown in Figure 2. The last challenge - communication - is determined based on consultation with participants in the program, both doctors and patients.

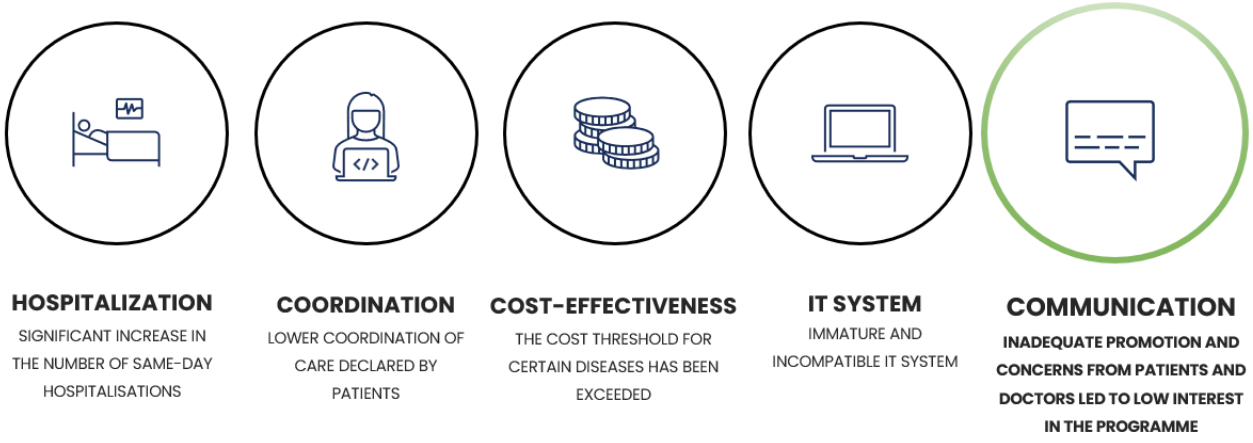

Fig 2. Selected problems identified in the coordinated care program in Poland.

Fig 3. Scalable process for increasing the functionality of the CORE system.

A prospective answer to the above problems seems to be a system based on artificial intelligence algorithms. A system that, by design, has a module for the GP, other specialists, and the patient. Our proposal is a system tentatively called the "CORE system" (from COordinated healthcaRE). The main idea behind the design of such a system is to take over the coordination tasks currently performed by a human. Conceptually, the CORE system is a platform that integrates elements of records management, patient education, communication, and coordination. The overall goals of the system are to effectively manage data, increase the healthcare facility's operational efficiency, improve communication between all stakeholders, and, consequently, improve the coordination of the treatment process. The main features and functionalities of the system are shown in Figure 3.

The system is based on core functionalities such as a communicator, a calendar, and a wizard for identifying patients potentially eligible for the diagnostic pathway within coordinated care. The communicator is designed to enable an efficient exchange of messages between the doctor and patients and between the general practitioner and other specialists. A similar solution, providing communication between doctors and patients, has been launched on the market as the Doctor.One application [14]. The communicator will allow the doctor to monitor the patient's condition after a newly prescribed medication or enable patients to express concerns about a new therapy. We believe it is essential for the doctor to have control over scheduling appointments and deciding when to address the patient's questions. This ensures a more effective and organized communication process. In addition, the communicator is a simple tool for consulting the patient's condition with other specialists - if the therapeutic pathway requires it. In a similar model - the specialist's response time - the attending physician can contact the specialist to address concerns without taking up the other specialist's time. Another element is the calendar and its ability to be managed by both healthcare professionals and the patient. Large private healthcare providers have introduced this type of solution.

The premise of this proposal is to facilitate both appointments and tests. The tool is programmed to give patients free access to appointments or diagnostic tests. In addition, the system sends messages to remind the patient of scheduled appointments. If necessary, the patient can inform the doctor of the need to cancel the appointment. A groundbreaking solution for increasing the effectiveness of coordinated care in primary care is integrating the CORE system with the IT systems on which the medical facilities operate. By providing access to the patient database, the system captures patients who could be included in the diagnostic pathway within coordinated care. This is an essential tool for increasing program participation. The system's ability to generate reports enables a doctor or health facility staff member to make contact and present the opportunities created by the coordinated care program.

The interdisciplinary nature of the CORE system also means that patient education materials can be uploaded and personalized according to the diagnostic pathway in which they are included. One of the main tasks of the coordinator is to monitor the implementation of IPOM. Of course, an artificial intelligence algorithm should also take over this responsibility. IPOM is integrated into the CORE system by design. On this basis, the system monitors the implementation of the following steps planned by the doctor for the patient. Suppose the patient does not follow the recommendations, and there are delays in the implementation of the next steps. In that case, the system reports any inaccuracies to the doctor and notifies the patient.

Another system feature is the ability to store and transfer patient test results. The CORE system thus

becomes a platform for exchanging medical information, where the patient and doctor have free access to the entire medical record. Such a solution facilitates the coordination of services. Once the test results have been sent to the doctor, they can analyze them and decide whether to invite the patient to the office for an additional appointment or to contact the patient via the communicator and comment on the results. Such a solution can potentially increase the capacity of today's already overburdened primary care units.

Stages three, four, and five are solutions that, to our knowledge, are not yet implemented in the global healthcare market. Mobile integration combines the CORE system with personal devices that monitor the patient's condition. These devices include smartwatches with ECG, pulse and saturation measurement, cough recording systems, blood glucose sensors, and many others. This solution allows the doctor to analyze the patient's condition in real time. It also makes it possible to create trend graphs of changes in patient condition. The latter is likely the result of the large amount of medical data that has been collected.

Stage four is the introduction of the Patient Outcome Analysis Assistant into the system. Based on the available data, the artificial intelligence algorithm analyses the results. It alerts the clinician to potential risks, results that still need to be ordered, or results that must be repeated due to their last performance date. At this stage, the system is integrated with commonly used algorithms and chronic disease risk assessment scales (e.g., SCORE or H2FPEF scale). The physician's daily workload often prevents them from screening patients and identifying those at risk of developing a particular disease entity. Based on the information contained in the system, the algorithm automatically substitutes scores into well-validated and commonly used scales. It then reports the risk to the physician, who can intervene with the patient after reviewing the information provided. This solution fulfills, to a certain extent, the preventive activity that is the basis for maintaining good health in society.

The culmination of the CORE system's functionality proposed in this paper is the creation of population data management capabilities. Reporting based on population data thus becomes an excellent tool for managing the health system in local and central contexts. For primary care unit owners and public policymakers, the generated reports become the basis for making decisions crucial for developing the coordinated care program.

However, like all digital-based systems, the "CORE system" also has some drawbacks and weaknesses identified by the conception authors.

Among the limitations are:

1. Dependence on Technology:

The system heavily relies on technology, which might pose challenges in areas with limited access to advanced infrastructure or in populations with low digital literacy. This dependency raises concerns about equity in healthcare access and the exclusion of specific demographics. Given that many patients in the health program described above are older adults who may be digitally excluded, we see a need for a new health coordination body. The Regional Health Care Coordination Centres are units established by local authorities (counties) that take over the tasks of the coordinators present in the POZs and complement the functioning of the CORE system. The units are responsible for coordinating the care process for patients who cannot effectively use the resources of the CORE system. However, these centers have the additional task of managing the CORE system - noting and implementing updates to the system and new functionalities. They combine the work of coordinators, data analysts (extracted from the CORE system), and IT staff working on the system. These centers would be publicly funded.

2. Privacy and Security Concerns:

Given the sensitive nature of medical data, the CORE system must provide robust privacy and security measures. However, any data security breach could lead to compromised patient confidentiality, identity theft, or misuse of medical information, potentially undermining confidence in the system. Implementing stringent data security protocols, including encryption, access controls, and regular audits, to safeguard patient information and mitigate the risk of data breaches is imperative, as well as compliance with regulatory standards such as the General Data Protection Regulation (GDPR).

3. Integration Issues:

Integrating the CORE system with existing healthcare IT infrastructure may encounter compatibility issues or require substantial resources for implementation. Incompatibility could result in data silos, inefficiencies, and disruptions in patient care.

4. User Adoption and Training:

Healthcare professionals and patients may require extensive training to utilize the CORE system effectively. Resistance to change, lack of tech-savviness, or inadequate training programs could hinder adoption, leading to underutilization and suboptimal outcomes.

5. Algorithm Bias and Accuracy:

The AI algorithms driving the CORE system must be continuously monitored and updated to mitigate biases and ensure accuracy. Biased algorithms could lead to erroneous medical decisions, exacerbating health disparities or causing harm to patients. It should, therefore, be emphasized that the CORE system is, by definition, an assistant for the doctor. It cannot and will not function to make therapeutic decisions or suggest a diagnosis. It can only support the doctor in diagnosing by pointing out deviations in reference ranges or providing epidemiological data and suggesting further tests. Moreover, the system operator must continuously evaluate the performance and impact of the CORE system through feedback mechanisms, clinical audits, and outcome assessments. The CORE system should be iteratively improved based on insights gathered from real-world usage and stakeholder feedback.

6. Limited Accessibility:

Despite its potential benefits, the CORE system may not be accessible to all patients, particularly those in rural or underserved areas with limited internet connectivity or financial constraints. This disparity could widen existing healthcare disparities rather than mitigate them. Due to that, initiatives to improve accessibility should be implemented, such as providing alternative communication channels for patients without internet

access or offering subsidies for internet connectivity and personal devices in underserved communities.

4. Conclusions

The solution proposed in this work is a highly innovative system based on artificial intelligence algorithms, which by design becomes a tool for coordinating primary care. We believe it fills in the problems coordinated care currently faces in Poland.

The CORE system is a solution that has the following advantages:

- It provides a platform for patients to easily communicate with their doctors and manage their appointment and examination calendars. It allows patients to manage their treatment process, including information on treatment recommendations, disease characteristics, and prevention of complications.
- For the physician, it is a tool to help coordinate treatment, provide easy access to patient records, prepare the IPOM, and monitor compliance with the IPOM. It also includes information on documentation deficiencies and self-reports worrying results.
- For POZ owners and public policymakers, it is a system for reporting and managing population data, allowing decisions about the program's development and future based on complex data collected locally and centrally.

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