



Review Article

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Challenges of Digital Management Systems in Medicine and Healthcare

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To Cite This Article: Avtandil Gagnidze*, Maksim Iavich, Iva Kereselidze and Lasha Shavradze. Challenges of Digital Management Systems in Medicine and Healthcare. Am J Biomed Sci & Res. 2025 27(4) AJBSR.MS.ID.003580, DOI: [10.34297/AJBSR.2025.27.003580](https://doi.org/10.34297/AJBSR.2025.27.003580)

Received: 📅 June 23, 2025; **Published:** 📅 June 27, 2025

Abstract

For the successful management of processes in modern medicine, as well as in all other areas, the development of electronic services is very important. For the medical field, this is especially important and relevant, since it consists of a large number of interconnected systems and components, the main goal of which is the health and life of people. This in itself requires maximum accuracy, proper functioning, reliability and security of any information about the patient from such systems. Due to the fact that a large part of the processes in medicine is decentralized and involve all the links involved in the process in various systems, programs, equipment and even paper carriers, searching for information, it is clear, in our opinion, the main principle: the management system should be as "one-window shop", "user friendly". All types of information, including all records about the patient, should be available in one window, and at the same time the system should be protected and secure.

Keywords: Digital Management, Clinic Management, Security

Introduction

Managing a clinic and a medical institution in general primarily involves the effective management of treatment and diagnostic processes and the implementation of full control over them. For the effective management of processes in modern medicine, as well as in all other areas, the development of electronic services is very important. It can be said that for the medical field it is especially important and relevant, because it consists of a large number of interconnected subsystems and components, the main goal of which is the health and life of people. Which requires maximum accuracy, proper functioning, reliability and security of any information about the patient for such systems. In the security part, one of the

most important things is that all events and processes should be carried out in such a way that we have the opportunity to see them sequentially. There should not be any object, record, action, transaction or even viewing information in the system that should not be logged. In Georgia, as well as in developed countries, there is a problem of information decentralization. Access to information is complicated and difficult to find and view in different systems or devices. Medical management methods are very fragmented and only partially include electronic processes.

In the modern world, the most important resource and factor has become time! The time factor is especially important for

healthcare, because human health does not/cannot wait and often requires immediate action: every minute and second lost here can cost us very dearly. Modern medical facility management involves interacting with a number of related, but very different structures, processes, data and systems, such as: ministries, banks, insurance companies, pharmaceutical organizations, finance, accounting, procurement, costs, other medical facilities, clinical trials, personnel management, IT, marketing, call center, operating room, outpatient clinic, inpatient clinic, diagnostics, laboratory, radiology, ultrasound, document flow, electronic signatures, queue management, other medical devices and software, medical forms, patient history, doctors, nurses, surgery, laboratory technicians, etc.

Objectives

The aim of the paper is to study the existing and most common digital management systems of medical institutions and analyze the processes. To assess the current state of affairs based on the study of diverse scientific literature. Thus, the subject of the presented research/review is digital management systems of medical institutions and their security. The objects of the research are medical institutions, their management processes and digital management systems.

Overview of Medical Facility Management Systems

Basics

Medical facility management primarily involves the implementation of control over medical diagnostic processes. For the correct management of processes in modern medicine, as well as in all other areas, the development of electronic services is very important. It can be said that for the medical field it is especially important and relevant, because it consists of a large number of interconnected systems and components, the main purpose of which is the health and life of people [18].

Therefore, the requirements for such systems in terms of maximum accuracy [9], correct and smooth functioning, reliability and security of any information about the patient are extremely important. One of the most important aspects of security [13] is that all events and processes should be carried out in a way that allows us to see them sequentially. There should be no object, record, action, transaction, or even view of information in the system that should not be logged [38].

The involvement and requirements of the state play a very important role in the development of electronic processes in any field. In 2019, the Ministry of Health of Georgia issued orders and instructions, which obliged medical institutions in the country to ensure that any type of patient medical record is in electronic form and must be uploaded to the portals of the Ministry of Health of Georgia. At the same time the state's requirements for electronic processes and data are still quite decentralized and also include physical carriers. Which means that this process is not fully developed and still requires a lot of work. At this stage, the state has sev-

eral fairly large e-portals: prescriptions, financing, medical cases, inpatient cases, emergency medicine, morphological laboratory studies, cancer registry, etc.

Due to the decentralization and diversity of systems, medical personnel involved in the healthcare process have to spend a lot of time learning different systems and then correctly finding and using patient information in these systems. In the modern world, time has become the most important thing! [43]. Time is especially important for healthcare, because human health does not/cannot wait and often requires immediate action, and every second and minute wasted here can cost us very dearly [31,32].

Medical Classification Systems

There are many types of diseases and medical services, because medicine is international and everyone needs it, so it must be easily understood in any country and in any language. For this, a communication "language" in the form of codes/classifiers has been created. Medical classification systems are essential tools used in the healthcare industry to organize and categorize medical data. These systems are used to classify diseases, symptoms, treatments, and procedures, and they play an important role in healthcare management, research, and reimbursement [12]. There are several different types of medical classification systems used in the healthcare industry. The most widely used is The International Statistical Classification of Diseases and Related Health Problems ICD, managed by the World Health Organization and is used to monitor the effectiveness of health programs and policies and to allocate resources to health services [46]. The use of the ICD system has several benefits in the health care field. It provides a standardized approach to classifying and coding medical conditions, which helps improve communication among health care professionals. It also helps improve patient care by providing a standardized approach to diagnosis and treatment [26].

In addition to its use in the health care field, the ICD system is also used in research. Using the ICD system, researchers can analyze large amounts of medical data to identify trends and patterns that can be used to improve healthcare outcomes [23]. The National Classification of Diseases (NCSP) is a medical classification system used to classify and code diseases, injuries, and causes of death. The NCSP system is based on the International Classification of Diseases (ICD) system. The NCSP system is used to collect and analyze data on morbidity and mortality. It is also used to monitor the effectiveness of health programs and policies and to allocate resources to health services. In addition to its use in healthcare, the NCSP system is also used in research. Using the NCSP system, researchers can analyze large amounts of medical data to identify trends and patterns that can be used to improve healthcare outcomes.

Special Healthcare Systems

In addition to above mentioned classification systems, there are also several other specialized systems used in healthcare. For example, the Diagnosis-Related Group (DRG) system is used to clas-

sify hospital cases into groups based on the patient's diagnosis, age, and other factors. This system is used to determine reimbursement rates for hospitals. The Diagnosis-Related Group (DRG) is a medical classification system used in healthcare to classify hospital cases into groups based on the patient's diagnosis, age, and other factors. The DRG system is used to determine reimbursement rates for hospitals and is widely used in the United States and other countries.

The DRG system was developed in the 1980s as a way to control healthcare costs and improve the quality of care. The system is based on the principle that patients with similar diagnoses and treatment plans should have similar hospital costs. The DRG system classifies hospital cases into groups based on the patient's diagnosis, age, and other factors and assigns a payment rate to each group. The DRG system consists of more than 700 groups, each with a specific payment rate. The payment rate for each group is based on the average cost of treating patients in that group. Hospitals are reimbursed based on the DRG group assigned to each patient, regardless of the actual cost of care. The use of the DRG system has several benefits in healthcare. It helps control healthcare costs by providing a standardized approach to reimbursement rates. It also helps improve the quality of care by encouraging hospitals to provide efficient and effective care. In addition to its use in healthcare reimbursement, the DRG system is also used in healthcare research. Using the DRG system, researchers can analyze large amounts of medical data to identify trends and patterns that can be used to improve healthcare outcomes.

Clinical Practice

In general, clinical practice consists of the following main types: outpatient consultations, examinations, prescriptions; day hospital types of operations, manipulations and procedures in which the patient does not stay in the clinic for more than 24 hours; inpatient types of operations, manipulations and procedures in which the patient stays in the clinic for more than 24 hours and requires intensive care under the supervision of doctors for a period of time; Emergency medicine is the direction when the patient's treatment, examination, operation is carried out immediately. In addition to medical personnel, many structural units are involved in the management of the clinic: personnel management, HR, marketing, central pharmacy, economics, finance, accounting, medical billing, procurement, registry, IT department, engineering, statistics, quality control, etc.

The structure of a medical institution is very different and diverse. In fact, every department of the clinic and even the department are separate, independent business processes that differ sharply from each other and are also closely interconnected. Therefore, it is practically impossible to manage it with a unified approach. Every country has its own approaches and rules regarding the conduct of healthcare processes, but in fact all of them are united under the idea and approach that this type of information is very personal and sensitive, therefore, the most important and first requirement for such electronic data and systems should be

data security, both its movement within the system itself, as well as the protection of the database, systems, connections and electronic environment from cyber-attacks. It is necessary to develop electronic services, systems, technologies and cyber security even more intensively, because the health and life of people are the most important and each result achieved here, each life saved is a great achievement and step for humanity. The development of technologies and electronic processes simplifies, improves, makes all processes more reliable and accessible.

The activities of a medical institution are one of the largest and most difficult to solve processes. Connections with various external systems, such as: Ministry of Health systems, payment systems, patient personal data, state services, financing, insurance companies, financial services, call centre, remote services, statistics, cloud services, etc. A medical institution has a large and complex document circulation structure, which can also be connected to external systems and services.

Laboratory Management Systems

Laboratory data is an integral part of the patient's treatment process. This is a world where you will encounter a lot of very different structures and contents of equipment, automated systems, semi-automated systems, modules, microscopes, laboratory assistants, etc [8]. Their structure is so different that here too we are dealing with the distribution of data in different systems, decentralization, which greatly hinders the process and makes it difficult to access one of the most necessary information. This type of information spread across systems makes their security more difficult and expensive [11]. In many cases, the security aspect is neglected and vital, necessary information is difficult to access, often lost or becomes a victim of hackers.

Also, one of the most important aspects of security is that all events and processes should be carried out in such a way that we have the opportunity to see them sequentially. There should be no object, record, action, transaction, or even view of information in the system that should not be logged [39]. Since most of the processes in medicine are decentralized and involve all the participants in the process in different systems, programs, equipment and even paper carriers, the main approach and problem of information retrieval [37]. It was identified, that the system should be as "one-stop shop" as possible [16] "User Friendly" All types of information, including all records about the patient, should be available in one window [22]. The patient's history should be consistent, easy to understand, should include all the necessary information for everyone, and its reliability should be very high. A patient's medical history consists of data obtained from all the above-mentioned systems and their correct distribution [45].

"Live Mode"

Due to the criticality and importance of the processes, the clinic management should have the opportunity to view and monitor all types of information and processes in "LIVE" mode [25]. Doctors

should also have access to such data in “LIVE” mode as: computed and magnetic resonance imaging, X-ray, laboratory, morphology, complete patient history: diagnosis, prescription, treatments performed, manipulations, operations and statistical data [4,19].

Such data will also be used for scientific and educational purposes [10]. For example, for the resident training process, as well as when a doctor is preparing a publication for an international publishing house or conference, he can very easily find the information he needs in the system and, based on it, prepare relevant material and share his experience. Through electronically connected services and automation, it should be easy for a doctor to view a patient's complete medical history in one window, which makes the patient's treatment process faster and more efficient. The treating doctor should be able to observe the patient in dynamics, generate more information, and easily view the results of tests or consultations performed around him at different times at the same time. At the same time, it will be easier for patients to use the clinic's services: registration, scheduling a visit to the doctor, receiving test results electronically, through remote communication channels (SMS, mail, call, cloud), and most importantly, the doctor will have more leverage, time, and opportunities to better manage the patient's treatment process.

For a unified electronic clinic management system, it is necessary that all data from various modules, devices, and programs be integrated into a single system and be quickly and easily accessible [5]. It is also necessary to unify these data and processes, because the electronic clinic management system is connected via secure VPN channels and communicates in an encrypted manner with many different types of sources and external systems and portals [44], which exchange data in “LIVE” mode [2,17].

Research Management Systems

One of the most important and complex systems in clinic management is the laboratory research system. Laboratory medicine is one of the fastest growing fields of modern medicine, where new methodologies, new equipment, and new approaches to clinical laboratory research are constantly being introduced [24,28]. Clinical laboratory research consists of many different areas. The main areas are: clinical laboratory, immunology, bacteriology, morphology, genetics, etc. Clinical laboratories play a crucial role in modern healthcare. Laboratories are responsible for performing diagnostic tests on patient samples to help doctors diagnose, treat, and prevent diseases [47,41]. Tests performed in clinical laboratories can range from routine blood tests to more complex genetic tests. These laboratories use advanced technology and equipment to analyze patient samples and produce accurate results [21,40]. One of the primary functions of clinical laboratory systems is to ensure the accuracy and reliability of test results. These systems use advanced technology and equipment to analyze patient samples and generate accurate results. They also provide quality control and assurance tools, such as automated instrument performance monitoring and proficiency testing.

Many studies have shown that a medical laboratory contains a large number of devices of different types and contents, which have significantly different data formats and structures [35,36,6]. They also have significantly different communication languages, channels and connections. The results of laboratory studies are personal patient data, which must be protected by a high level of security of all types [7]. Laboratory equipment should operate in a well-protected and restricted network environment and security monitoring should be carried out systematically. Damage, loss, and disclosure of this data should be excluded as much as possible. Each step, change, deletion, and even viewing should be logged so that the process works correctly and smoothly. It is useful and necessary for the laboratory to unite all laboratory equipment under a single software and then connect it to a single clinic management system in the appropriate sequence and should be included in the patient's anamnesis (the patient's complete medical history) so that the doctor and relevant medical personnel can view all the necessary studies and records of the patient's life in one window in the appropriate order and sequence. In the process of treating a patient, laboratory research results are one of the most important data for a doctor to make an accurate diagnosis and select treatment. The presence of a digital laboratory management module significantly simplifies patient access to laboratory services and increases the reliability of laboratory test results [27,33,42].

As a rule, the digital laboratory management system works with the help of “barcodes”. When registering for a patient's examination, a unique adhesive “barcode” is registered in the system and printed, which is attached to the patient's examination. The laboratory technician attaches this to the test tube containing the patient's biological material to be examined and places this test tube in the laboratory research device. The laboratory device reads the “barcode” attached to the test tube and connects to the system via an encrypted channel. The system transmits to the research device which specific “barcodes” to conduct. The laboratory device begins conducting the examination and, after completing the examination, returns the response to the same unique “barcode” to the system, which processes the received data according to specific patients, since the norms of laboratory research answers depend on various data of a specific patient. For example: age, weight, blood group and rhesus, height, etc. Laboratory medicine in general is one of the fastest developing fields, where new methodologies, equipment, and new approaches to clinical laboratory research are being introduced.

Main Threats and Challenges

Security

One of the most significant threats in healthcare data systems is unauthorized access, which encompasses both identity spoofing and privilege misuse. Spoofing involves an adversarial actor impersonating a legitimate user such as a doctor, nurse, or administrator to gain access to sensitive patient records or system resources. This could occur through stolen credentials, social engineering, or by ex-

exploiting weak authentication mechanisms. Closely related to spoofing is the broader risk of unauthorized data access, which includes cases where an insider or external actor bypasses access control policies to view or modify data beyond their legitimate scope. In healthcare, such breaches directly impact patient privacy and can lead to violations of data protection regulations like.

Another major category of risk involves threats to data integrity and system availability. Data tampering refers to unauthorized modification of clinical records, diagnostic data, or administrative transactions. For instance, an attacker might alter test results or prescription details, undermining clinical decision-making and threatening patient safety. In real healthcare environments, data tampering can also compromise audit trails, making it difficult to track or reverse malicious changes [34].

In parallel, Denial of Service (DoS) attacks target the availability of critical system resources. Such attacks can overwhelm APIs or database layers, leading to delays in accessing vital patient data and disrupting clinical workflows. In urgent care scenarios, even brief disruptions can have severe consequences, highlighting the critical need for resilient and robust system design. It should be emphasized that for the electronic clinic management system, it is very important to manage the patient's electronic medical personal data and bring it into compliance with standards so that sensitive information is not disclosed/publicized and used dishonestly. Electronic signatures and encryption [15,20,29] have become necessary for digital processes in any field and in medicine particularly. Patients confirm a number of permissions and consents to conduct medical processes by signing. Accordingly, a digital system cannot be fully digital if it contains a physical paper carrier. By integrating electronic signatures into the system, it becomes possible to produce such documents digitally and safe.

Using Cloud

PACS (Picture Archiving and Communication Systems) is a system used to connect servers, computers, and medical devices to store, retrieve, use, and manage medical radiological images. PACS systems work with images in different formats. The most common format in PACS systems is the Digital Imaging and Communications Format (DICOM). PACS (Picture Archiving and Communication System) is a medical imaging technology that is primarily used in healthcare organizations to securely store and use electronic images and clinically important information by medical personnel.

PACS image information systems have replaced the need to store and manage printed materials and media in shelves and rooms. Instead, medical images, medical records, and other clinical data can be securely stored digitally on-premises or in the cloud. A cloud-based PACS stores and archives medical imaging data on a company's secure server. This is required by the HIPAA security rule in the US, which regulates the 35 of patient information. A cloud-based PACS also allows medical staff to view medical imaging data from any additional device, such as a PC, notebook, tablet, and smartphone. Providers often use a hybrid cloud system, in which

primary images are stored on-premises and backups are stored in the cloud. Additional types of storage architecture and security can be configured and attached to the PACS server, such as Direct Attached Storage (DAS), Network Attached Storage (NAS), or Storage Area Network (SAN), each of which provides the ability to be updated, connected, upgraded, and provide additional security.

The workflow in PACS systems is as follows: the patient is registered in the system with personal data, the study to be conducted, and a specific doctor. Then the doctor/assistant starts the patient's study. During the study, he/she monitors the patient and the imaging process in the program and, if necessary, adds additional programs to the study (studies consist of programs) or restarts specific programs. After the study is completed, the doctor conducts a detailed examination of each medical image. Determines the size and structure of organs and deviations. Marks/measures areas of interest and clinically important. Determines the anatomy of the organs to be studied. After that, he/she writes the conclusion in the program and finally completes the study. If the system is connected to a CD-ROM writer and a medical tape printer, the system automatically sends the study to an external drive (CD Disk) for recording and printing on a tape.

PACS systems are presented as stand-alone software and not part of a single clinic management system. This makes it difficult to access some of the most important patient information, as doctors have to work in several programs and it is difficult to see the image in a unified view. It is also difficult to get this information into other related systems and report on it. PACS systems are quite expensive to maintain. Because the size of medical images is often quite large and can be several gigabytes. To work stably, it requires powerful processors, a lot of RAM, even more HDDs, a well-protected and fast network environment. Server and network infrastructure are crucial for the correct and fast functioning of such systems. In many cases, all medical devices and PACS servers are in a confined network to avoid overloading the network with additional traffic, data loss and system slowdown.

AI and Machine Learning

The US Food and Drug Administration (FDA) has issued several recommendations for the use of "Good Machine Learning Practices" (GMLP) [14] when developing artificial intelligence. Excerpt from the recommendation: "While these recommendations are not official FDA regulations or even project guidelines, they are useful guidelines for developers. The first two recommendations address the availability of high-quality and focused datasets, clinically meaningful data, proper organization and sequencing, and consistency. Then, the intended use and modification. In short, the data should be carefully selected, used, and have direct relevance to the clinical problem. It should be noted that creating the right database for AI can be achieved by working with clinicians and other medical personnel, who should be involved in the machine learning process.

Artificial Intelligence (AI) is becoming increasingly prevalent in medicine [30,1]. AI refers to the use of computer algorithms and

machine learning techniques to analyze data and make predictions or recommendations. In medicine, AI can be used to improve patient outcomes, increase efficiency, and reduce costs [3]. One of the main applications of artificial intelligence in medicine is diagnostic imaging. Artificial intelligence algorithms can analyze medical images such as X-rays, and Artificial Intelligence (AI) is becoming increasingly common in medicine. AI refers to the use of computer algorithms and machine learning techniques to analyze data and make predictions or recommendations. In medicine, artificial intelligence can be used to improve patient outcomes, increase efficiency, and reduce costs. Artificial intelligence algorithms can analyze large data sets to identify potential drug candidates and predict their effectiveness. This can help speed up the drug discovery process and reduce the cost of developing new drugs.

AI can also be used to improve healthcare operations. For example, artificial intelligence algorithms can be used to optimize patient scheduling, predict patient demand for services, and improve chain management. For proper management of patient flow in medical processes, the ability to book appointments is essential. As it turned out, a clinic does not only need to book doctor visits. It also needs to manage operating room appointments, manage manipulations, manage hospital rooms and beds, manage meeting rooms, manage conference rooms, and a queue system that should be connected to the doctor's appointment booking functionality. The doctor's appointment booking functionality, queue management system, and the clinic's unified electronic management system should be interconnected in such a way that when the doctor orders the next tests and redirects the patient to another destination, the booking or queue system should be automatically reflected. Another important feature of these systems is queue management. Queue management systems use real-time data to monitor patient flow and optimize wait times. This feature can help reduce patient wait times and improve the patient experience. Patients can also receive real-time updates about wait times, which can help reduce anxiety and improve patient satisfaction.

Financial Management and Billing

Medical financial management systems are software applications designed to manage the financial processes associated with medical services provided to patients. One of the key features of a medical financial management system is the ability to manage patient records and insurance information. These systems can store patient demographics, insurance information, and billing history, allowing healthcare providers to easily access this information when needed. This helps ensure that claims are submitted accurately and on time. Another important feature of medical financial management systems is the ability to automate many of the manual tasks involved in billing and payment processing. These systems can automate tasks such as data entry, claim submission, and payment posting, which can help reduce errors and improve efficiency. This can also free up staff time and resources for other important tasks.

Medical financial management systems also include modules for claims processing, payment posting, and reporting. Payment posting involves recording payments received from insurance companies and patients. Reporting involves generating reports on billing activity, payment trends, and revenue performance. One of the main benefits of using a medical financial management system is that it can help healthcare providers reduce administrative costs. By automating many of the manual tasks involved in billing and payment processing, these systems can reduce errors and improve efficiency, which can lead to cost savings for healthcare providers. Clinic management is unthinkable without medical billing. Medical billing encompasses the complete financial movement of a patient, including billing. It is important for medical billing to analyze the entire revenue cycle. Each part of the medical billing process represents information that is collected before a patient receives a service. Each phase of the revenue cycle is from the moment the patient receives a prescription until the payment is made by the insurance company.

Conclusions

The development of electronic processes in medicine does not have a long history and there is still a lot to be studied and developed. Due to the decentralization and diversity of systems, medical personnel involved in the healthcare process have to spend a lot of time learning different systems and then correctly finding and using patient information in these systems. It is critically important to further develop digital services, systems, technologies, and cybersecurity in the healthcare sector, because human health and lives are the most important, and each result achieved here, each life saved is a great achievement and step forward for humanity. The development of technologies and electronic processes simplifies, improves, makes more reliable, and accessible all processes. All laboratory equipment should be combined under a single software and then connected to a single clinic management system in the appropriate order and included in the patient's complete medical history so that the doctor and relevant medical personnel can view all the necessary studies and records of the patient's life in one window in the appropriate order and sequence.

Artificial intelligence (AI) is becoming increasingly common in medicine. AI involves the use of computer algorithms and machine learning techniques to analyze data and make predictions or recommendations. Artificial intelligence in medicine can be used to improve patient outcomes, increase efficiency and reduce costs. Artificial intelligence is playing an increasingly important role in medicine. AI can be used to improve patient outcomes, increase efficiency, and reduce costs. Applications of artificial intelligence in medicine include diagnostic imaging, personalized treatment planning, drug discovery, and optimization of healthcare operations.

Acknowledgement

Study was conducted with support of East-West University, Tbilisi, Georgia.

Conflict of Interest

None.

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