Information technology in health care delivery: an overview

Joshua F Eniojukan

Department of Clinical Pharmacy and Pharmacy Practice, Faculty of Pharmacy,
Niger Delta University, Wilberforce Island, Bayelsa State. Nigeria

Corresponding author: Joshua F. Eniojukan
Email: joshuaeniojukan98@gmail.com
Telephone: +234 813 9452206
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ABSTRACT

Background: The use of electronic processes in healthcare dated back to at least the 1990s. Usage of the term varies as it covers not just "Internet medicine" as it was conceived during that time, but also "virtually everything related to computers and medicine". A study in 2005 found 51 unique definitions. Some argue that it is interchangeable with health informatics with a broad definition covering electronic/digital processes in health while others use it in the narrower sense of healthcare practice using the Internet. It can also include health applications and links on mobile phones, referred to as mHealth or m-Health.

Objective: This paper reviewed the several facets of health information technologies (HIT), Health Informatics (HI), electronic Health (eHealth), Pharmacy Informatics and their place in improving patient and therapy management, patient outcomes, and access to medical care.

Methods: Literature databases such as Elsevier, Pubmed, Scopus, Google Scholar, BioMed Central, and ScienceDirect were engaged in the review work. The specific keywords related to the review were identified and used.

Results: Clear evidence exists on the growing impact that eHealth has on the delivery of health care around the world today, and how it is making health systems more efficient and more responsive to people's needs and expectations. With the increasing involvement of clinicians in the day-to-day running of health care delivery, interest is now focused on Electronic Health Record as a key area for improving clinical efficiency. For the healthcare practitioner, the subspecialty of clinical informatics is most relevant. Given the ongoing advances in information technology, the field of informatics is becoming important to clinical practice and to residency education. As technology continues to advance and evolve, the impact of informatics in health care will continue to grow.

Conclusion: The future of medical informatics is promising and many healthcare professionals should have a background in informatics. Pharmacy informatics, a subset of health informatics, leverages both clinical expertise and knowledge about information technology to improve medication management processes and drug administration safety.

Les technologies de l'information dans la prestation des soins de santé : un aperçu

Joshua F. Eniojukan

Département de pharmacie clinique et de pratique pharmaceutique, Faculté de Pharmacie,
Université du Delta du Niger Île Wilberforce, État de Bayelsa. Nigeria

Auteur correspondant: Joshua F. Eniojukan
Courriel: joshuaeniojukan98@gmail.com
Téléphone: +2348139452206

RÉSUMÉ

Contexte: L'utilisation de processus électroniques dans le domaine des soins de santé remonte au moins aux années 1990. L'usage du terme varie car il couvre non seulement la " médecine sur Internet " telle qu'elle était conçue à cette époque, mais aussi " pratiquement tout ce qui est lié aux ordinateurs et à la médecine ". Une étude réalisée en 2005 a recensé 51 définitions uniques. Certains soutiennent qu'elle est interchangeable avec l'informatique de la santé avec une définition large couvrant les processus électroniques/numériques dans le domaine de la santé, tandis que d'autres l'utilisent dans le sens plus étroit de la pratique des soins de santé utilisant Internet . Il peut également inclure des applications et des liens de santé sur les téléphones mobiles, appelés mSanté ou m-santé.

Objectif: Cet article a passé en revue les différentes facettes des technologies de l'information pour la santé (TIS), de l'informatique de la santé (IS), de la santé numérique (SN), de l'informatique pharmaceutique et leur rôle dans l'amélioration de la gestion des patients et des thérapies, des résultats pour les patients et de l'accès aux soins médicaux.

Méthodes: les bases de données bibliographiques telles que Elsevier, Pubmed, Scopus, Google Scholar, BioMed Central et ScienceDirect ont été utilisées pour le travail d'analyse. Les mots-clés spécifiques liés à l'examen ont été identifiés et utilisés.

Résultats: Il existe des preuves claires de l'impact croissant de la santé numérique sur la prestation de soins de santé dans le monde entier et de la manière dont elle rend les systèmes de santé plus efficaces et plus réactifs aux besoins et aux attentes des populations. Avec l'implication croissante des cliniciens dans la gestion quotidienne de la prestation des soins de santé, l'intérêt se porte désormais sur le dossier médical électronique en tant que domaine clé pour améliorer l'efficacité clinique. Pour le professionnel de la santé, la sous-spécialité de l'informatique clinique est la plus pertinente. Compte tenu des progrès constants des technologies de l'information, le domaine de l'informatique devient important pour la pratique clinique et la formation des internes. À mesure que la technologie continue de progresser et d'évoluer, l'impact de l'informatique dans les soins de santé continuera à se développer.

Conclusion: L'avenir de l'informatique médicale est prometteur et de nombreux professionnels de la santé devraient avoir une formation en informatique. L'informatique pharmaceutique, un sous-ensemble de l'informatique de la santé, tire parti à la fois de l'expertise clinique et des connaissances en technologies de l'information pour améliorer les processus de gestion des médicaments et la sécurité de leur administration.

INTRODUCTION

Information technology (IT) is the study or use of systems for storing, retrieving, and exchanging information. IT covers any form of technology, that is, any equipment or technique used by a company, institution, or any other organization which handles information. It incorporates computing, telecommunication technologies, and includes consumer electronics and broadcasting as it is getting more and more digitized.[1-3]

IT is opined to have the potential of transforming academic health centers (AHCs) by making health care more effective at meeting the needs of individual patients.

IT in health care has delivered a number of benefits to both healthcare providers and patients.[4,5]

Health Information Technology (Health IT)

Health information technology (Health IT) is observed to be "the application of information processing involving both computer hardware and software that deals with the storage, retrieval, sharing, and use of health care information, health data, and knowledge for communication and decision making".[6]

Health IT involves the processing, storage, and exchange of health information in an electronic environment Health IT involves maintaining computer systems and their associated programs; and using those programs to achieve better patient outcomes and to understand trends and perceptions in the field of healthcare.

In its entirety, Health IT is seen as the application of technology in the healthcare industry for the purpose of storing, retrieving, and sharing healthcare information6.

Why is Health IT important?

The push for the development of HIT was borne from the belief that HIT would improve accountability, patient and population health outcomes, and healthcare delivery efficiencies while augmenting the ongoing effort to decrease healthcare costs. Health IT makes information accessible, actionable, timely, customizable, and portable. Rapid access to information also creates efficiencies in care by eliminating redundancies and illuminating health history and prior care.[7-13]

Some basic applications of Health IT include:

I. Laboratory information system [LIS]

A laboratory information system (LIS) is computer software that processes, stores and manages data from all stages of medical processes and tests.

LIS is actually a software which receives, processes and stores information generated by the laboratory workflow. It automates the workflow of all information related to total testing process.

A good Laboratory Information Management System should have three main components:

- Sample Tracking,
- Protocol Execution, and
- Storage Organization.

It is unimaginable for a laboratory in which samples are tracked differently by different researchers, using methods varying between a pen and paper and a massive spreadsheet.[14-16]

II. Computerized physician order entry (CPOE)

Computerized physician order entry (CPOE), also known as computerized provider order entry or computerized practitioner order entry refers to the process of providers entering and sending treatment instructions - including medication, laboratory, and radiology orders - via a computer application rather than paper, fax, or telephone.[17-19]

Most CPOE systems allow providers to electronically specify medication orders as well as laboratory, admission, radiology, referral, and procedure orders. On its own, CPOE has an impact on safety by ensuring that orders are legible.

Benefits of CPOE

CPOE can help:

- **Reduce errors and improve patient safety:** At a minimum, CPOE can help your organization reduce errors by ensuring providers produce standardized, legible, and complete orders. In addition, CPOE technology often includes built-in clinical decision support tools that can automatically check for drug interactions, medication allergies, and other potential problems.

- **Improve efficiency:** By enabling providers to submit orders electronically, CPOE can help your organization get medication, laboratory, and radiology orders to pharmacies, laboratories, and radiology facilities faster, saving time and improving efficiency.

III. GP2GP

GP2GP allows patients' electronic health records to be transferred directly, securely, and quickly between their old and new practices, when they change GPs. This improves patient care by making full and detailed medical records available to practices, for a new patient's first and later consultations.[20]

Benefits

- Full electronic health record available for the patient's first and subsequent consultations. This improves continuity of care for on-going medical conditions
- No need for patients to provide a detailed account of their previous medical history to their new clinician, as the integrated electronic health record is visible
- Safer prescribing provided by access to the patient's current and past medication and to any recorded allergies and adverse reactions
- Repeat medication details will be available for the patient's first medication review with the new GP
- GP2GP allows the NHS to preserve the usability of rich data accumulated in patient records

IV. Electronic sign-out and hand-off tools

Sign-out or "hand-over" communication relates to the process of passing patient-specific information from one caregiver to another, from one team of caregivers to the next, or from caregivers to the patient and family for the purpose of ensuring patient care continuity and safety. Breakdown in handover of patient information has been found to be one of the leading root causes of sentinel events in the United States. Electronic sign-out applications are tools used as standalone or integrated with the electronic medical record to ensure a structured transfer of patient information during healthcare provider handoffs. Two systematic reviews evaluating outcomes of electronic tools supporting physician shift-to-shift handoffs concluded that most studies supported using an electronic tool with an improvement in the process of handover, fewer omissions of critical patient information and reduced handover time when using the electronic tool with few low-quality studies assessing patient outcome measures.[21-23]

V. Bar code medication administration

Bar code medication administration systems are electronic systems that integrate electronic medication administration records with bar code technology. These systems are intended to prevent medication error by ensuring that the right patient receives the right medication at the right time. Furthermore, there are varying levels of sophistication among existing barcode systems. For example, some software produces alerts when sound-alike or look-alike medications may be confused. Others provide clinical advisories for specific medications when scanned, and others may assist with documentation (namely, recording drug administration in the eMAR and other relevant clinical details)[24,25]

VI. Smart pumps

Smart pumps are intravenous infusion pumps that are equipped with medication error-prevention software. This software alerts the operator when the infusion setting is set outside of pre-configured safety limits. The only published randomized controlled trial on the impact of smart pumps on medication safety has shown that there was no statistical difference between activating the decision support feature on or off the smart pump. The authors had explained that this was likely in part due to poor compliance of healthcare providers to infusion practices. A systematic review of quasi-experimental studies concluded that smart pumps may reduce programing errors but they do not eliminate such errors. The review also found that hard limits were more effective than soft limits in preventing medication errors. This was explained by the high override rate of soft limits. Further robust studies are needed to make a conclusion of the efficacy of smart pumps on reducing medication errors and improving patient's safety.[26,27]

VII. Automated medication dispensing technology

Automated dispensing cabinets (ADC) are electronic drug cabinets that store medication at the point of care with controlled dispensing and tracking of medication distribution. Automated dispensing cabinets were fist used in hospitals in the 1980s, but have evolved over time to include more sophisticated software and digital interfaces to synthesize high-risk steps in the medication dispensing process. Automated medication dispensing cabinets have been successfully used as a medication inventory management tool that help in automating the medication dispensing process by minimizing the workload on the central pharmacy and keeping better track of medication dispensing and patient billing.[28]

VIII. Patient electronic portals

A patient portal is a secure online application that provides patients access to their personal health information and 2-way electronic communication with their care provider using a computer or a mobile device. Numerous studies have shown that patient portals improve outcomes of preventive care and disease awareness and self-management. However, there is no evidence that they improve patient safety outcomes.[29-32]

IX. Telemedicine

Telemedicine is defined as the use of telecommunication technologies to facilitate patient to provider or provider to provider communication. Communication maybe synchronous with real-time 2-way video communication or asynchronous transmission of patient clinical information. In addition to communication, telemedicine may provide health information that is collected remotely from medical devices or personal mobile devices. This information may be used to monitor patients, track or change their behavior.[33]

X. Synchronous telemedicine

Virtual visits are real-time 2-way audio/video communication between a healthcare provider and a patient. Numerous systematic reviews have studied the impact of virtual visits on patient outcomes in critical care, chronic disease care, and psychiatric care. All have showed that telemedicine is as effective as face-to-face care with regard to specific clinical outcomes but there is limited evidence regarding patient safety outcomes. An e-consultation is an electronic communication between the patient's primary care clinician and a specialist using a secure communication platform. This technology facilitates guidance from the specialist regarding the management of the patient without the need for referring the patient. There is limited evidence about the efficacy and safety of e-consults, but studies have shown that e-consults may reduce patient wait times for specialist appointments and opinions.[34-39]

XI. Remote patient monitoring

Studies evaluating community based Remote patient monitoring (telemonitoring) have shown that it improves patient outcomes for certain chronic conditions including; heart failure, stroke, COPD, asthma and hypertension. Patient data management system (PDMS) are systems that automatically retrieve data from bedside medical equipment (namely patient monitor, ventilator, intravenous pump, and so forth). The data is subsequently summarized and restructured to aid healthcare providers in interpreting the data. Recent advances in integration have allowed PDMS to be integrated with clinical decision support and the patient's electronic medical record. A systematic review studied the clinical impact of PDMS and found that such systems increased the time spent on direct patient care by reducing the time spent on charting. In addition, PDMS systems reduced the occurrence of errors (medication errors, ventilator incidents, intravenous incidents, and other incidents). The review also found that 2 articles reported an improvement in clinical outcomes when a PDMS was integrated with a clinical decision support system. Research shows that telemedicine technology seems to improve clinical outcomes for certain medical conditions and, seems to enhance accessibility to healthcare services and foster patient-physician collaboration.[40-44]

XII. Electronic incident reporting

Electronic incident reporting systems are web-based systems that allow healthcare providers who are involved in safety events to voluntarily report such incidents. Such systems can be integrated with the electronic health record (EHR) to enable abstraction of data and automated detection of adverse events through trigger tools. Electronic incident reporting systems potentially have the following advantages; standardize reporting structure, standardize incident action workflow, rapid identification of serious incidents and trigger events, while automating data entry and analysis. Published research shows that healthcare organizations that have moved to an electronic reporting system have experienced a significant increase in reporting frequency. Incident reporting systems may improve clinical processes, but there is little evidence that electronic reporting systems ultimately reduce medical errors.[45,46]

INFORMATICS[47,48]

The term **"informatics"** broadly describes the study, design, and development of information technology for the good of people, organizations, and society. It is the study of the behavior and structure of any system that generates, stores, processes and then presents information.

It involves the practice of information processing and the engineering of information systems. The field considers the interaction between humans and information. Informatics has a social impact on information technologies.

There are many aspects to Informatics, and actually encompasses a number of existing academic disciplines like Artificial Intelligence, Cognitive Science and Computer Science. Each takes part of Informatics as its natural domain. Whilst Cognitive Science is concerned with the study of natural systems, Computer Science is associated with the analysis of computation, and design of computing systems. On the other hand, Artificial Intelligence plays a connecting role, designing systems which emulate those found in nature.

Informatics also informs and is informed by other disciplines, such as Mathematics, Electronics, Biology, Linguistics and Psychology.

Summarily, Informatics provides a link between disciplines with their own methodologies and perspectives, bringing together a common scientific paradigm, common engineering methods and a pervasive stimulus from technological development and practical application.

Notably, the following are closely associated with the functions and attributes of Informatics:

- Gathering and manipulating data and information are the initial processes of informatics.
- Storing and retrieving data and information are essential processes of informatics.
- Classifying recorded information is a process of informatics.[47,48]

Health informatics

Health informatics (HI) is defined as the discipline that researches, formulates, designs, develops, implements, and evaluates information-related concepts, methods, and tools (e.g., ICT) to support clinical care, research, health services administration, and education.

HI (also called **medical *informatics***), focuses on information technology to positively impact the patient - physician relationship.

It is essentially the interprofessional field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem-solving, decision making, motivated by efforts to improve human health.

HI can well be seen as the communication and use of information in the health care sector with the help of computer science.

It represents a steadily growing aspect of biomedical engineering in visceral medicine.

Biomedical or clinical informatics is regarded as the transdisciplinary field that studies and develops effective uses of biomedical data, information technology innovations, and medical knowledge for scientific inquiry, problem solving, and decision making, with an emphasis on improving human health.

It has been regarded as an interprofessional practice that blends medical practice with information technologies and behavioral management principles. Far from being regarded as a rigid academic or technical pursuit, clinical informatics is a practical discipline that improves patient outcomes, advances medical research, and increases the value of healthcare delivery. The key to these goals is the understanding that the successful evolution of health care is determined not by technical capability, but by how effectively the technology is designed and integrated into existing cultures, regulatory frameworks, and institutional workflows.

Though clinical informatics has been practiced since the 1950s, it was not until the internet era that the discipline began achieving widespread consideration and application outside academics.[49-53]

THE IMPACT OF INFORMATICS IN HEALTH CARE

Technology has contributed in no small measure to the rapid improvement of health care globally. Just as technology has precipitated tremendous improvements in fields like business or the sciences, it has no doubt made treating patients easier and more effective than ever.

From telemedicine to patient records, informatics has had a serious impact on health care.

Specifically, Informatics has caused dramatic influence on how medical professionals deliver care to patients as well as how health care teams operate on a daily basis. Starting from basic clinical operations on to administration and coordination, no sector in the medical field that isn't in some way influenced or enhanced through health care informatics. The indisputable fact is that by allowing health care providers and medical professionals to easily share knowledge and information, informatics enable safer and overall better patient care.

There are several tools for patient engagement which have the potential to transform care into an active collaboration between providers and patients, with the goal of improving standards of care. These tools include but not limited to the following:

Electronic health records	Patient-facing online portals	Online health tutorials
Wearable monitor/trackers	Mobile health apps	Telehealth platforms
Secure messaging	Video conferencing	Social media platforms

Specific examples include: NextMD, WebMD, MyHealtheVet, OpenNotes; Omada, Fitbit, Apple Watch, Active blood glucose monitoring, AmericanWell TigerText, BlueJeans PatientsLikeMe RateMDs, Yelp, ZocDoc

Enhancing patient engagement has been shown to directly impact patient behavior that promotes positive health outcomes, patient satisfaction, care delivery efficiency, improved quality of care and patient safety as well as reduce costs.

Further, informatics can help:

- optimize communication for residents,
- promote information technology use,
- refine documentation techniques,
- reduce medical errors,
- improve clinical decision making, and
- enable practitioners to maximize their ability to provide quality care to their patients.[4,54]

The Convenience of Informatics

From a patient standpoint, informatics in health care enables medical professionals to provide a better experience. Thanks to electronic health records (EHRs), all pertinent patient data is stored in secure, easy to access electronic systems, which in turn makes care both quicker and more comprehensive, even when a patient has multiple health providers. Rather than needing patients to remember every detail of their medical history or spend time filling out extensive paperwork, health care providers can retrieve the medical history, materials and records themselves.

Informatics and EHRs also lead to safer care and better outcomes, as they can reduce the risk of error when it comes to prescribing medication and other sensitive tasks. With electronic records more readily available, telehealth - remote health care - becomes more accessible, since sensitive medical information can be shared virtually. Finally, by streamlining the tools, data, and methods needed to diagnose and treat patients, health care informatics make it easier for health care providers to increase their efficiency without sacrificing the quality of care.

A distinct benefit of Informatics is that it helps Patients take Control of their own Healthcare.

Informatics in health care increases patient participation. By providing patients with easy ways to access their own health records and other resources, informatics help patients to take charge of their own health.

The more control and information patients have about their conditions, the easier it is for them to play an active role in their health and wellness.

By sharing knowledge, health care informatics help to establish a more transparent, consistent collaborative medical field, both for medical staff and patients. This applies to medical staff and health care teams, as well as patients and their providers.

Medical informatics can be an important tool to control and address public health concerns using an interprofessional team of physicians, nurses, pharmacists, and public health workers. Some examples include patients missing immunizations or tracking the proper use of controlled substances.

As a practical discipline, clinical informatics has far-reaching applications within the healthcare framework-individual physicians, multi-center hospital systems, medical insurance firms, government agencies, medical device developers and more are all potential beneficiaries.[55-57]

Electronic Health Record (EHR): Perhaps the most publicly high-profile application of clinical informatics is the universal adoption of the EHR.

Since it must record every patient encounter, medication ordered, and laboratory test performed, the EHR impacts every aspect of a healthcare institution's operations.

Predictive Medicine: One of the most promising potential applications of clinical informatics is the development of predictive medicine. Predictive medicine is the science of accurately risk-stratifying an individual for developing the disease within a specified time-frame.

While predictive capabilities traditionally revolved around genetics (e.g. karyotype testing for Down Syndrome, BRCA gene testing for breast cancer), clinical informatics has helped to usher in a new era of predictive medicine based on so-called Big Data, huge quantities of data obtained from a variety of disparate sources in real-time. Predictive tools based on big data has the potential to help clinicians better predict who will get sick when and how best to intervene before the patient becomes sick. Though healthcare has yet to develop its own predictive tools, Target Corporation, a major retailer, has already developed a big-data informatics system that predicts when a customer is pregnant; the company subsequently tailors its marketing efforts towards those customers accordingly.

Clinical Research Informatics

Clinical research informatics (CRI) is a sub-field of health informatics that tries to improve the efficiency of clinical research by using informatics methods. Some of the problems tackled by CRI are: creation of data warehouses of health care data that can be used for research, support of data collection in clinical trials by the use of electronic data capture systems, streamlining ethical approvals and renewals (in US the responsible entity is the local institutional review board), maintenance of repositories of past clinical trial data (de-identified). CRI is a fairly new branch of informatics and has met growing pains as any up and coming field does. Some issue CRI faces is the ability for the statisticians and the computer system architects to work with the clinical research staff in designing a system and lack of funding to support the development of a new system.

There are a number of activities within clinical research that CRI supports, including:

- more efficient and effective data collection and acquisition
- improved recruitment into clinical trials
- optimal protocol design and efficient management
- patient recruitment and management
- adverse event reporting
- regulatory compliance
- data storage, transfer, processing and analysis
- repositories of data from completed clinical trials (for secondary analyses)

Clinical Research Informatics involves the use of informatics in the discovery and management of new knowledge relating to health and disease. It includes management of information related to clinical trials and also involves informatics related to secondary research use of clinical data.[58-60]

Translational bioinformatics

Translational Bioinformatics (TBI) is a relatively new field that surfaced in the year of 2000 when human genome sequence was released. The commonly used definition of TBI is lengthy and could be found on the AMIA website. In simpler terms, TBI could be defined as a collection of colossal amounts of health-related data (biomedical and genomic) and translation of the data into individually tailored clinical entities. Today, TBI field is categorized into four major themes:

- Clinical big data is a collection of electronic health records that are used for innovations. The evidence-based approach that is currently practiced in medicine is suggested to be merged with the practice-based medicine to achieve better outcomes for patients.
- **Genomics in clinical care**
  Genomic data are used to identify the genes involvement in unknown or rare conditions/syndromes. Currently, the most vigorous area of using genomics is oncology. The identification of genomic sequencing of cancer may define reasons of drug(s) sensitivity and resistance during oncological treatment processes.
- **Omics for drugs discovery and repurposing**
  Repurposing of the drug is an appealing idea that allows the pharmaceutical companies to sell an already approved drug to treat a different condition/disease that the drug was not initially approved for by the FDA. The observation of "molecular signatures in disease and compare those to signatures observed in cells" points to the possibility of a drug ability to cure and/or relieve symptoms of a disease.
- **Personalized genomic testing**
  In the US, several companies offer direct-to-consumer (DTC) genetic testing. The company that performs the majority of testing is called 23andMe.
- Utilizing genetic testing in health care raises many ethical, legal and social concerns; one of the main questions is whether the health care providers are ready to include patient-supplied genomic information while providing care that is unbiased (despite the intimate genomic knowledge) and a high quality. The documented examples of incorporating such information into a health care delivery showed both positive and negative impacts on the overall health care related outcomes.[61]

ELECTRONIC HEALTH RECORDS (EHRs)

EHRs are shareable systematized collection of patient and population-stored health information in a digital format. They are one of the most important tools the modern healthcare delivery system has to improve patient safety.

An electronic health record (EHR) contains patient health information, such as:

- Administrative and billing data
- Patient demographics
- Progress notes
- Vital signs
- Medical histories
- Diagnoses
- Medications
- Immunization dates
- Allergies
- Radiology images
- Lab and test results

An EHR is more than just a computerized version of a paper chart in a provider's office. It's a digital record that can provide comprehensive health information about your patients. EHR systems are built to share information with other health care providers and organizations - such as laboratories, specialists, medical imaging facilities, pharmacies, emergency facilities, and school and workplace clinics - so they contain information from all clinicians involved in a patient's care.

Electronic health records (EHRs) are increasingly being deployed as digital inpatient information systems of clinical and administrative data. The interplay of social and technical factors is important when considering effective implementation and adoption strategies in busy, complex hospital environments. These systems offer considerable potential to enhance the safety, quality, and efficiency of hospital healthcare provision.

EHR systems contain medical records, prescription data, and sometimes lifestyle information (e.g., smoking status) from diverse practitioners and facilities. Health information is organized into sets of notes and coded information used for diagnosis and treatment.[55,56]

HER facilitates Research

The Institute of Medicine has identified eight core functions of Electronic Health Records (EHRs)69.

1. Health information and data

EHRs replace paper medical records with electronic clinical and demographic information on patients. With an EHR, you get rapid access to patient data like medical history, diagnoses, allergies, medications, and test results. Because EHRs can hold more data than paper records, medical histories can be more complete, improving care.

2. Results management

Filing lab results in the appropriate paper medical record can be time-consuming, cause errors, or lead to misplaced results. A core function of EHRs is to simplify results management, making testing more efficient, and improving patient care. EHRs, like NextGen Healthcare Information Systems, give you faster access to lab results, allowing your practice to recognize and address abnormal results faster. An EHR will also reduce redundant testing by automatically displaying previous lab results. An EHR also lets you share test results with patients and other providers and import them into your EHR. This automated results- sharing improves patient engagement and care coordination.

3. Order entry and management

Computerized physician order entry (CPOE) is another core function of EHRs. Within an EHR system, you can order lab tests, prescription drugs, radiology, and even consults. Studies have shown that computerized provider order entry can improve workflow and reduce errors. For example, electronic orders can end lost orders and confusion from illegible handwriting. An EHR can also flag suspected duplicate orders, and it can generate related orders automatically. This reduces the time to fill orders, thereby increasing patient satisfaction and care quality. Electronic orders can also save money by eliminating the costs of producing and filing paper forms for orders and results. Filing electronic prescription drug orders through your EHR can also improve your practice. EHRs with e-prescribing reduce medication errors. Your EHR will flag medication doses or frequencies outside of the recommended range. An EHR will also check the proposed medication against the patient's record. This automated check flags potential allergies or interactions with existing medications.[62-68]

4. Clinical decision support

EHRs provide two major types of decision support: Reminders and alerts and computer-assisted diagnosis and treatment. Reminders and alerts include the following:

- Flags for potentially inappropriate medication doses or frequencies
- Alerts about potential drug interactions

- Reminders to clinicians to provide appropriate preventive care screenings

These clinical quality measure tools can reduce errors and improve prevention in your practice.

Computer-assisted diagnosis, treatment, and disease management tools are more sophisticated. Diagnostic tools can help guide clinicians through the diagnosis of complex conditions. Using these tools, your practice can reduce the time it takes for a patient to receive a diagnosis and reduce the frequency of misdiagnosis. Decision support tools can also help busy clinicians provide guidelines-based care. For example, your EHR can find and display clinical guidelines based on diagnosis entry. Also, EHR decision support tools can flag treatment plans and orders that may not adhere to the latest clinical guidelines. By adhering to guidelines, your practice can improve care quality and reduce claims denials. Clinical decision support can help your practice improve care quality, reduce errors, and get to diagnosis and treatment faster. These tools can increase your quality scores, patient satisfaction, and practice efficiency.[70-72]

5. Electronic communication and connectivity
promise faster, easier access to patient medical records and sharable data. EHRs allow you to share data with other providers, improving care coordination. You can also share data with patients to increase their engagement in their care. EHRs can facilitate patient education and encourage self-management. EHRs also have built-in electronic messaging, patient portal, and email connectivity. This allows for quick communication both among providers and between providers and patients. Providers can easily share lab results, request referrals, direct messaging, and email questions. This rapid communication among providers improves care coordination and reduces duplicative testing. EHRs also enhance patient-provider communication, making patients more engaged in their care. Through an EHR Patient Portal, your patients can message their provider, see lab results, and schedule appointments.[73-75]

6. Patient support
Patient education and support are essential for managing chronic conditions. Your EHR can help you provide appropriate and timely patient education. EHRs can host a library of educational materials for easy access. They can also generate follow-up instructions and treatment plans, so patients know their next steps. EHR Patient Portals can also help patients access electronic education materials and treatment plans. Finally, EHR systems can also integrate with telehealth and telemonitoring programs. These programs can help your practice track patient progress between office visits.

7. Administrative processes
An EHR can help your practice improve scheduling, billing, and claims management. For example, patients make appointments electronically, without calling your office. You can also customize your EHR to allow electronic patient registration, reducing patient wait times. Electronic registration also reduces your data entry time by requiring patients to enter their own data. An HER can also help your practice streamline billing and claims management practices. For example, your EHR can validate a patient's insurance coverage for tests and medications, reducing coverage denials. EHRs can also help you request prior approval and authorizations, reducing wait times. Finally, EHR clinical decision support tools can improve your practice's adherence to guidelines-based care. This can reduce claims denials and improve quality scores.

8. Reporting and population health management
If your practice accepts multiple insurance types, you likely face many reporting requirements. For example, under Medicare, many practices participate in the Quality Payment Program (QPP). The QPP requires annual reporting of a variety of quality measures. An EHR can help you fulfill your reporting requirements more easily. EHRs can draw data from across your system without the need for manual data entry or pulling from paper charts. An EHR can also help you manage your patient population's health by giving your practice simple access to key quality indicators. For example, can help you track population health metrics of interest to your practice. Through regular monitoring, you can identify problem areas and address them quickly. In this way, Dashboards can help you improve your efficiency and the quality of care you provide.[76,77]

Advantages of Electronic Health Records
EHRs and the ability to exchange health information electronically can help you provide higher quality and safer care for patients while creating tangible enhancements for your organization. EHRs help providers better manage care for patients and provide better health care by:

- Providing accurate, up-to-date, and complete information about patients at the point of care
- Enabling quick access to patient records for more coordinated, efficient care

- Securely sharing electronic information with patients and other clinicians
- Helping providers more effectively diagnose patients, reduce medical errors, and provide safer care
- Improving patient and provider interaction and communication, as well as health care convenience
- Enabling safer, more reliable prescribing
- Helping promote legible, complete documentation and accurate, streamlined coding and billing
- Enhancing privacy and security of patient data
- Helping providers improve productivity and work-life balance
- Enabling providers to improve efficiency and meet their business goals
- Reducing costs through decreased paperwork, improved safety, reduced duplication of testing, and improved health.

Other Advantages
Transformed Health Care

Electronic Health Records (EHRs) are the first step to transformed health care. The benefits of electronic health records include:

- ***Better health care*** by improving all aspects of patient care, including safety, effectiveness, patient-centeredness, communication, education, timeliness, efficiency, and equity.
- ***Better health*** by encouraging healthier lifestyles in the entire population, including increased physical activity, better nutrition, avoidance of behavioral risks, and wider use of preventative care.
- ***Improved efficiencies and lower health care costs*** by promoting preventative medicine and improved coordination of health care services, as well as by reducing waste and redundant tests.
- ***Better clinical decision making*** by integrating patient information from multiple sources.[78,79]

Public Health Informatics

Public health informatics developed out of the related disciplines of medical informatics and bioinformatics. It is defined as the systematic application of information, computer science, and technology to public health practice, research, and learning. With the rapid pace of information technology development, new applications of public health informatics contribute to more timely and accurate data for disease surveillance. Examples include electronic laboratory reporting of notifiable diseases, aided by new data transmission standards and vocabularies; personal digital assistants or handheld computers to collect data in the field that can be downloaded into a database with no further data entry requirements; geographic information systems integrated with satellite images to provide information about the spread of diseases; use of mobile telephones to report surveillance data from the field, especially in resource-limited countries; and use of the Internet as an effective way to share surveillance data with health professionals, researchers, members of the public, and the media.

Along with these new opportunities, increasing use of information technology for public health surveillance faces many challenges, such as ensuring appropriate governance structures to protect confidentiality and privacy; providing storage capacity for increasingly large quantities of data; managing increasingly complex and costly systems associated with computer software and hardware; and the growing need for trained public health informatics professionals. As many health systems move toward the implementation of electronic patient medical records, specialists in public health informatics are needed to realize the potential of such data for public health surveillance.

In developed countries like the United States, public health informatics is practiced by individuals in public health agencies at the federal and state levels and in the larger local health jurisdictions. Additionally, research and training in public health informatics takes place at a variety of academic institutions.

At the federal Centers for Disease Control and Prevention in US states like Atlanta, Georgia, the Public Health Surveillance and Informatics Program Office (PHSIPO) focuses on advancing the state of information science and applies digital information technologies to aid in the detection and management of diseases and syndromes in individuals and populations.

The bulk of the work of public health informatics may include: collection and storage of vital statistics (birth and death records); collection of reports of communicable disease cases from doctors, hospitals, and laboratories, used for infectious disease surveillance; display of infectious disease statistics and trends; collection of child immunization and lead screening information; daily collection and analysis of emergency room data to detect early evidence of biological threats; collection of hospital capacity information to allow for planning of responses in case of emergencies.

Since about 2005, the CDC has promoted the idea of the Public Health Information Network to facilitate the transmission of data from various partners in the health care industry and elsewhere (hospitals, clinical and environmental laboratories, doctors' practices, pharmacies) to local health agencies, then to state health agencies, and then to the CDC. At each stage the entity must be capable of receiving the data, storing it, aggregating it appropriately, and transmitting it to the next level. A typical example would be infectious disease data, which hospitals, labs, and doctors are legally required to report to local health agencies; local health agencies must report to their state public health department; and which the states must report in aggregate form to the CDC. Among other uses, the CDC publishes the Morbidity and Mortality Weekly Report (MMWR) based on these data acquired systematically from across the United States.

Major issues in the collection of public health data are: awareness of the need to report data; lack of resources of either the reporter or collector; lack of interoperability of data interchange formats, which can be at the purely syntactic or at the semantic level; variation in reporting requirements across the states, territories, and localities.

Public health informatics can be thought or divided into three categories.[80-83]

a. Study models of different systems

The first category is to discover and study models of complex systems, such as disease transmission. This can be done through different types of data collections, such as hospital surveys, or electronic surveys submitted to the organization (such as the CDC). Transmission rates or disease incidence rates/surveillance can be obtained through government organizations, such as the CDC, or global organizations, such as WHO. Not only disease transmission/rates can be looked at. Public health informatics can also delve into people with/without health insurance and the rates at which they go to the doctor. Before the advent of the internet, public health data in the United States, like other healthcare and business data, were collected on paper forms and stored centrally at the relevant public health agency. If the data were to be computerized they required a distinct data entry process, were stored in the various file formats of the day and analyzed by mainframe computers using standard batch processing.

b. Storage of public health data

The second category is to find ways to improve the efficiency of different public health systems. This is done through various collections methods, storage of data and how the data is used to improve current health problems. In order to keep everything standardized, vocabulary and word usage needs to be consistent throughout all systems. Finding new ways to link together and share new data with current systems is important to keep everything up to date.

Storage of public health data shares the same data management issues as other industries. And like other industries, the details of how these issues play out are affected by the nature of the data being managed.

Due to the complexity and variability of public health data, like health care data generally, the issue of data modeling presents a particular challenge. While a generation ago flat data sets for statistical analysis were the norm, today's requirements of interoperability and integrated sets of data across the public health enterprise require more sophistication. The relational database is increasingly the norm in public health informatics.

Designers and implementers of the many sets of data required for various public health purposes must find a workable balance between very complex and abstract data models such as HL7's Reference Information Model (RIM) or CDC's Public Health Logical Data Model, and simplistic, ad hoc models that untrained public health practitioners come up with and feel capable of working with.

c. Analysis of public health data

Finally, the last category can be thought as maintaining and enriching current systems and models to adapt to overflow of data and storing/sorting of this new data. This can be as simple as connecting directly to an electronic data collection source, such as health records from the hospital, or can go public information (CDC) about disease rates/transmission. Finding new algorithms that will sort through large quantities of data quickly and effectively is necessary as well.

The need to extract usable public health information from the mass of data available requires the public health informaticist to become familiar with a range of analysis tools, ranging from business intelligence tools to produce routine or ad hoc reports, to sophisticated statistical analysis tools such as DAP/SAS and PSPP/SPSS, to Geographical Information Systems (GIS) to expose the geographical dimension of public health trends. Such analyses usually require methods that appropriately secure the privacy of the health data. One approach is to separate the individually identifiable variables of the data from the rest

eHealth

eHealth is defined as the delivery of health care using modern electronic information and communication technologies when health care providers and patients are not directly in contact and their interaction is mediated by electronic means.[56]

In a definite sense, eHealth describes healthcare services which are supported by digital processes, communication or technology such as electronic prescribing, Telehealth, or Electronic Health Records. The use of electronic processes in healthcare dated back to at least the 1990s.

WHO defines **eHealth** as the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research.

e-health has been viewed as an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology.

eHealth summarily describes healthcare services which are supported by digital processes, communication or technology such as electronic prescribing, Telehealth, or Electronic Health Records (EHRs).

The use of electronic processes in healthcare dated back to at least the 1990s. Usage of the term varies as it covers not just "Internet medicine" as it was conceived during that time, but also "virtually everything related to computers and medicine".

A study in 2005 found 51 unique definitions. Some argue that it is interchangeable with health informatics with a broad definition covering electronic/digital processes in health while others use it in the narrower sense of healthcare practice using the Internet.

It can also include health applications and links on mobile phones, referred to as mHealth or m-Health.

Among other things, the services that are thus provided include physical and psychological diagnosis and treatment, telepathology, vital signs monitoring, electronic prescribing, teleconsultation, etc. This approach to health care is increasingly being employed in geographically extended areas where the availability of health care is severely reduced or even non-existent, and when appropriately qualified medical personnel are available only in a centralized location.[84-89]

Types of eHealth

The term can encompass a range of services or systems that are at the edge of medicine/healthcare and information technology, including:

- **Electronic health record:** enabling the communication of patient data between different healthcare professionals (GPs, specialists etc.);
- **Computerized physician order entry:** a means of requesting diagnostic tests and treatments electronically and receiving the results
- **ePrescribing:** access to prescribing options, printing prescriptions to patients and sometimes electronic transmission of prescriptions from doctors to pharmacists
- **Clinical decision support system:** providing information electronically about protocols and standards for healthcare professionals to use in diagnosing and treating patients
- **Telemedicine:** physical and psychological diagnosis and treatments at a distance, including telemonitoring of patients functions and videoconferencing;
- **Telerehabilitation:** providing rehabilitation services over a distance through telecommunications.
- **Telesurgery:** use robots and wireless communication to perform surgery remotely.
- **Teledentistry:** exchange clinical information and images over a distance.
- **Consumer health informatics:** use of electronic resources on medical topics by healthy individuals or patients;
- **Health knowledge management:** e.g. in an overview of latest medical journals, best practice guidelines or epidemiological tracking (examples include physician resources such as Medscape and MDLinx);
- **Virtual healthcare teams:** consisting of healthcare professionals who collaborate and share information on patients through digital equipment

(for transmural care);

- **mHealth or m-Health:** includes the use of mobile devices in collecting aggregate and patient-level health data, providing healthcare information to practitioners, researchers, and patients, real-time monitoring of patient vitals, and direct provision of care (via mobile telemedicine);
- **Medical research using grids:** powerful computing and data management capabilities to handle large amounts of heterogeneous data.
- **Health informatics / healthcare information systems:** also often refer to software solutions for appointment scheduling, patient data management, work schedule management and other administrative tasks surrounding health. There can be integrated data collection platforms for devices and standards and require extended research.
- Internet Based Sources for Public Health Surveillance (Infoveillance).[90-94]

The 10 e's in "e-health"

1. **Efficiency -** one of the promises of e-health is to increase efficiency in health care, thereby decreasing costs. One possible way of decreasing costs would be by avoiding duplicative or unnecessary diagnostic or therapeutic interventions, through enhanced communication possibilities between health care establishments, and through patient involvement.

2. **Enhancing quality** of care **-** increasing efficiency involves not only reducing costs, but at the same time improving quality. E-health may enhance the quality of health care for example by allowing comparisons between different providers, involving consumers as additional power for quality assurance, and directing patient streams to the best quality providers.

3. **Evidence based -** e-health interventions should be evidence-based in a sense that their effectiveness and efficiency should not be assumed but proven by rigorous scientific evaluation. Much work still has to be done in this area.

4. **Empowerment** of consumers and patients **-** by making the knowledge bases of medicine and personal electronic records accessible to consumers over the Internet, e-health opens new avenues for patient-centered medicine, and enables evidence-based patient choice.

5. **Encouragement** of a new relationship between the patient and health professional, towards a true partnership, where decisions are made in a shared manner.

6. **Education** of physicians through online sources (continuing medical education) and consumers (health education, tailored preventive information for consumers)

7. **Enabling** information exchange and communication in a standardized way between health care establishments.

8. **Extending** the scope of health care beyond its conventional boundaries. This is meant in both a geographical sense as well as in a conceptual sense. e-health enables consumers to easily obtain health services online from global providers. These services can range from simple advice to more complex interventions or products such a pharmaceuticals.

9. **Ethics -** e-health involves new forms of patient-physician interaction and poses new challenges and threats to ethical issues such as online professional practice, informed consent, privacy and equity issues.

10. **Equity -** to make health care more equitable is one of the promises of e-health, but at the same time there is a considerable threat that e-health may deepen the gap between the "haves" and "have-nots". People, who do not have the money, skills, and access to computers and networks, cannot use computers effectively. As a result, these patient populations (which would actually benefit the most from health information) are those who are the least likely to benefit from advances in information technology, unless political measures ensure equitable access for all. The digital divide currently runs between rural vs. urban populations, rich vs. poor, young vs. old, male vs. female people, and between neglected/rare vs. common diseases.[87]

*Importantly, e-healt*h enables consumers to easily obtain health services online from global providers.

In developing countries, eHealth in general, and telemedicine in particular, is a vital resource to remote regions of emerging and developing countries but is often difficult to establish because of the lack of communications infrastructure. For example, in Benin republic and some parts of the Niger Delta region of Nigeria, hospitals often can become inaccessible due to flooding during the rainy season and across Africa, the low population density, along with severe weather conditions and the difficult financial situation in many African states, has meant that the majority of the African people are badly disadvantaged in medical care. In many regions there is not only a significant lack of facilities and trained health professionals, but also no access to eHealth because there is also no internet access in remote villages, or even a reliable electricity supply.

Internet connectivity, and the benefits of eHealth, can be brought to these regions using satellite broadband technology, and satellite is often the only solution where terrestrial access may be limited, or poor quality, and one that can provide a fast connection over a vast coverage area.[95-97]

PHARMACY INFORMATICS

Pharmacy informatics is defined by the American Society of Health-System Pharmacists (ASHP) as the integration and use of knowledge, information, technology, data and automation in the medication-use process.

Pharmacy informatics is defined by Healthcare Information and Management Systems Society (HIMSS) as "The scientific field that focuses on medication-related data and knowledge within the continuum of healthcare systems-including its acquisition, storage, analysis, use and dissemination-in the delivery of optimal medication-related patient care and health outcomes."

The practice is meant to streamline patient care and outcomes while enhancing efficiency and accuracy in the administration of medications.

Often coinciding with the use of electronic health records (EHR), pharmacy informatics is being used to replace paper-and-pen prescriptions to provide more precision and clarity for medication suppliers. Although not perfect, this technological practice has fast proven itself effective as an aid to error prevention while streamlining operations, information sharing and more.

The main core function of Pharmacy Informatics is bridging the gap between technology and the actual practice to assure optimal use and maximize the benefit of the adopted technology in the pharmacy practice.

Below are some examples of what pharmacy informatics could cover:

1. EMR Implementation, maintenance and support; especially pharmacy part of it and also covers the prescribing and administration part as it includes medications. "this accounts for huge part of pharmacy informatics practices worldwide."
2. EMR Clinical Content optimization and development.
3. The clinical Decision support system
4. Order sets/ protocols development
5. Formulary management
6. Pharmacy Automation Implementation, Operation, Maintenance, and Support.
7. Analyze and make decisions on the hardware or automation needed to support medication management workflows "Acquisition /request for proposal skills"
8. Training and education for all different system.

A Pharmacy informatics staff might work with different types of robotics systems, computerized provider order entry (CPOE) systems, pharmacy information systems, bar-code medication administration (BCMA) technology, inventory management systems, smart pumps or automated dispensing cabinets. It is a diverse field!

In a nutshell, Pharmacy Informatics Professionals can be called as "Technology Enablers" in the medication management arena. They are equipped to be the pharmacy department's source of informatics knowledge, skills, and abilities needed to serve health system information technology, automation and data management needs.

Examples of the effective use of pharmacy informatics include:

- Use of technology to make smart pumps even smarter
- Use of informatics to better program alert alarms while reducing the risk for infusion pump programming errors related to high-risk medications.
- Use of Computerized Prescriber Order Entry (CPOE) systems to gain better control over prescriptions for controlled substances. This system requires a two-factor authentication in order for controlled drugs to be prescribed.
- Use of an electronic medical records (EMR) system to provide post-discharge pharmacy consultations remotely. This has opened the door for more collaborative practice wherein a physician can order medications and provide the pharmacist access to the entire patient record for review of current medications, patient medical history, laboratory information, and more.[98-101]

REQUIRED COMPETENCIES

Five core competencies have been defined by ASHP that promote a technologically optimized medication-use process that is safe, effective, efficient, and timely:

I. data, information, and knowledge management;
ii. information and knowledge delivery;
iii. practice analytics;
iv. applied clinical informatics; and
v. leadership and management of change[7,102]

Automated medication dispensing technology

Automated dispensing cabinets (ADC) are electronic drug cabinets that store medication at the point of care with controlled dispensing and tracking of medication distribution. Automated dispensing cabinets were fist used in hospitals in the 1980s, but have evolved over time to include more sophisticated software and digital interfaces to synthesize high-risk steps in the medication dispensing process. Automated medication dispensing cabinets have been successfully used as a medication inventory management tool that help in automating the medication dispensing process by minimizing the workload on the central pharmacy and keeping better track of medication dispensing and patient billing. The impact of ADC on patient's safety is limited, as there is only one published controlled trial,[26] which found that the use of ADC resulted in a 28 % ($p<0.05$) reduction in the rate of medication errors in a hospital critical care unit (RR: 0.7; NNT: 4). Detailed analysis revealed that most reduced errors were preparation errors. The automated dispensing system did not reduce errors causing harm. Automated dispensing cabinets seem to reduce medication preparation errors in critical care setting. Although the level of evidence is high, it is however only limited to critical care setting. Further controlled studies are needed to make a conclusion on the impact of ADC on medication safety in other settings.[28]

CONCLUSION

As technology and innovation continue to rapidly shape health care and medication management, the need for specialized roles to support and optimize clinical workflows, system usage, and data capture is ever more important. Health informatics is an established field that bridges health care with information technology as a means to improve clinical care, ensure patient safety, and increase the efficiency and effectiveness of organizational processes.

Pharmacy informatics, a subset of health informatics, leverages both clinical expertise and knowledge about information technology to improve medication management processes and drug administration safety. The use and continued exploration of new technologies in the pharmaceutical field allows practitioners to carry out their mission to provide care for their patients through effective: Prescription management. Drug distribution. Inventory management & monitoring.

Health IT has become essential to the pharmacy industry, dramatically changing the way medications are ordered and dispensed while creating value. It enables and supports transformational changes in pharmacists' roles, both in traditional pharmacies and those associated with value-based care organizations. Health IT facilitates increased pharmacist involvement for patient care, which will cut costs and improve outcomes.

All of us-as health care providers and as patients can look forward to a brighter future enabled by technology.

In conclusion, health information technology improves patient safety by reducing medication errors, reducing adverse drug reactions and improving compliance to practice guidelines. There should be no doubt that health information technology is an important tool for improving healthcare quality and safety, but healthcare organizations need to be selective in which technology to invest in, as literature shows that some technologies have limited evidence in improving patient safety outcomes.

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