Introduction to Information and Computer Science: Information Systems

Lecture 2 Audio Transcript

Slide 1
Welcome to Introduction to Information and Computer Science: Information Systems.

The component, Introduction to Information and Computer Science, provides a basic overview of computer architecture; data organization, representation and structure; structure of programming languages; networking and data communication. It also includes basic terminology of computing.

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The objectives for this unit, Information Systems are to:

- Define an information system, how one is used and list examples.
- Describe the components of an information system.
- Describe the process for developing an information system.
- Describe the different types of testing and when testing should occur.
- Describe how information systems are supported and maintained over time.
- Describe specialized information systems.
- Explain how information systems are used in healthcare.

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This lecture focuses on specialized information systems and how information systems are used in healthcare.

There are many specialized information systems employed by business, science and medical institutions. The first, knowledge management systems, attempts to store and report knowledge instead of data or information. An example of a knowledge management system would be a collect of medical journal articles. Expert systems use artificial intelligence and knowledge to provide solutions to problems and will be described on the next slide. Virtual reality systems are simulations where users are immersed in the simulated environment and use natural realistic interactions. These are a different interface to information and problem solving. Virtual systems are widely used in healthcare for training, in surgery and for telemedicine.

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Expert systems use rules and directed input from the user to support decision making. They are composed of three parts: a knowledge base, an inference engine and an interface. The knowledge base is the set of rules that the expert system knows. The inference engine takes these rules and produces reasoning based on them. Often, the system needs additional input from the user during the reasoning process. The user interface is key for getting information from the user. Expert systems are used in medicine for diagnoses, prescribing medication and for decision making. In order for
computers to act intelligently, they must have extensive knowledge. This knowledge must be represented in a way that it can be easily retrieved.

There are many applications of expert systems in healthcare; clinical decision support is the name given to these systems. They can provide support for diagnosis, treatment and medication decisions.

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There are many expert systems used in healthcare; they are commonly used for clinical decision support for prescribing medication. The systems check for allergies, drug interactions and dosage recommendations.

A unique expert system is IBM Watson, IBM's intelligent computer system. It is being adapted to be an expert decision support system in healthcare. It will analyze massive amounts of up to date information such as journal articles, studies, similar cases, clinical and laboratory findings to help medical personnel make decisions in patient care.

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There are many different types of information systems used in healthcare settings today. A large hospital, for example, may have dozens of them. Some are very small and specific, like those that support medical equipment like electroencephalograms, or EEGs. Others are large and broad such as the business financial systems. Together, they support and connect the different business operations, healthcare practices and settings. The systems must be well connected within the institution, as well as externally in order to communicate information outside the institution. Finally, because patient data is so sensitive, the information systems must be secure and private.

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Information systems in healthcare have a variety of functions and goals. First of all, information systems such as human resources, financial operations, and inventory maintenance support the business operations of a hospital or healthcare institution. Secondly, systems support the operations related to healthcare such as scheduling, billing, reporting for accreditation, and physician ordering. They also provide clinical documentation through the use of electronic health records.

Communication is an important goal of healthcare systems and it encompasses different types of communication between providers, between patients and providers, and between institutions for communicating patient data and for supporting telemedicine.

Healthcare systems improve patient care and safety in a variety of ways--alerts and reminders for orders, pharmacy allergy and drug interaction checks, care management activities, and monitoring systems in the operation room (OR), to name a few.

Finally, information systems aim to provide security within the healthcare setting. This includes computer security and security of patient data, but it also includes things like controlling access to rooms or floors of a hospital and patient tracking.
It is common for one hospital to support dozens of different information systems; all or many of them may be bundled together by a single vendor or each of the systems may be from a different company.

This slide shows a list of some of the information systems that can be found in a hospital.

The first is a hospital's business information systems. This includes the information systems needed to keep the hospital business running, such as the financial and human resource information systems.

Registration systems coordinate all inpatient and outpatient activities in the hospital. Registration systems send messages to other systems every time the patient signs in for an appointment, is admitted to the hospital, and when there are changes to a patient’s demographic or billing data. These are called Admit Discharge Transfer (ADT) messages.

Scheduling systems manage patient appointments and are crucial for the functioning of different departments. The Master Patient Index (MPI) assures that patients are identified across all systems in the hospital and different units of hospital systems.

Laboratory information systems (LIS) help manage the data and processes within scientific laboratory settings. For example, hospitals have labs that can analyze patient blood draws or perform gene sequencing for research. Laboratory information systems are used for managing data within the lab and for processing orders and communicating results to and from other systems. A pathology reporting system is one type of LIS.

Imaging information systems manage the large amounts of image data collected electronically, such as x-rays, MRIs and CAT scans. They must support PACS, the Picture Archiving and Communication System, which is used to store and access electronic images.

Pharmacy information systems (PIS) can be complex and often involve robots. Pharmacies receive orders, check orders for problems with drug-to-drug interactions, make sure that the patient does not have allergies, mix IV fluid (often robotically), package and dispense to wards, manage billing and supplies, as well as manage communication with providers.

Biomedical equipment, such as EKG machines, have their own information systems for managing and interpreting the data collected during monitoring. In addition, this equipment is used for monitoring patients heart rate, blood pressure and ventilator settings, to name a few.

Clinical decision support systems are often integrated with the electronic health record. Alerts and reminders are common decision support tools and are often used for preventive health services. They also have many other uses, like suggesting ancillary orders, for example, lab tests that should be performed when certain drugs are given. Diagnostic decision support tools (like Dxplain and Mycin, which are very old systems) are generally standalone and are not integrated with EHRs. Drug-to-drug interaction and allergy checking are decision support tools that may be used by pharmacies or in
the EHR when ordering medications. "Smart" order sets help providers make the right decisions when ordering labs and medications.

Finally, electronic health records (EHR) manage the data related to a particular patient. They are used to both collect data and to display data that is collected in other information systems such as labs, EKGs, etcetera.

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Connecting all these systems is crucial for the system to work together as a whole. In order for this to occur, there must be standards for the messages that are sent from system to system, such as the HL7 standards for medical data and the DICOM standards for medical images. There must also be standards for terminology so that it is consistent across systems.

Next, there must be a high bandwidth network connecting the systems to facilitate the communication between systems, particularly those that are sending and receiving large amounts of data, such as images.

Finally, different systems must communicate with each other using an interface. If each system has a separate interface with every other system, there would be many, many interfaces within one system. Instead, systems can be connected using one interface engine which handles all the interfaces between the systems, greatly simplifying the complexity of the interfaces.

Since healthcare data is highly sensitive, all of the connections need to be secure. They must be reliable since healthcare systems must be up and running while the institution is open (hospitals are open 24 hours a day, 7 days a week) and they are crucial to all business and healthcare operations. This includes patient records, schedules, medications, as well as bio-equipment and monitoring systems that keep patients alive. Finally, the connections must be efficient and run as fast as possible.

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This slide shows a simplified diagram of the information systems at a hospital; the diagram is meant to be representative, not comprehensive. In the upper left corner, there are the central healthcare systems: the electronic health record (EHR), the master patient index (MPI), the scheduling system, the registration system and the billing system. These typically connect to one central server. On the right are the administration systems that support the hospital; these include everything from human resources (HR) systems, to executive information systems (EIS) to logistics systems to accounting and reimbursement systems.

Along the bottom are the many ancillary systems that are used in the different healthcare settings in the hospital. These include laboratory information systems, systems used for monitoring and testing cardiac conditions, systems used in the intensive care unit (ICU) and operating rooms (OR) and the PACS systems used for imagining. There are many other systems that could be included in this category. Because there are so many systems that need to interface with other ancillary systems and the other healthcare and administration systems, the ancillary systems commonly connect to an interface engine, which in turn connects to all the other systems.

Courtesy of Oregon Health & Science University and the ONC Health IT Workforce Curriculum program
Finally, all the groups of systems also connect to the Internet for external operations, such as communicating medical data to and from other institutions and connecting to outside systems for reimbursement.

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One of the smaller pieces of a hospital information system is the imaging information systems. At the center of the imaging information system is PACS, the Picture Archiving and Communication System. When an image is needed, the computerized physician order entry system (CPOE) within an EHR places an order for the image to the scheduling and registration systems. These systems also interact with the imaging modality system and the PACS for coordination of the appointment information. Then, the PACS takes input images from different imaging modalities, stores them and communicates them to different entities. For example, there are PACS viewers like the review station in the diagram on this slide that will display the electronic images. These images can be archived and stored, transferred to media such as CDs and DVDs, printed, and communicated back to the EHR in the form of a report or communicated to external specialists for review.

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Another system that is part of a hospital information system is the pharmacy information system or PIS. The pharmacy information system is responsible for coordinating all the activities related to the pharmacy operations, including the management of prescriptions, maintenance of the inventory of medications, and the generation of reports. The pharmacy usually has a clinical decision support system (CDS) that automatically checks for allergies and drug-to-drug interactions. In addition, the pharmacy may have electronic dispensing systems facilitated by robots.

The pharmacy information system communicates with the EHR and processes and manages orders received from the CPOE. The PIS also communicates with systems within the hospital related to patient care, such as the electronic medication administration record (eMAR) which keeps track of administered medications, electronically controlled infusion pumps, and dispensing cabinets.

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Not shown on the diagram on the previous slide, is another piece of the information systems at a hospital - the data warehouse system. Data warehouse systems are a collection of data from across an institution. Queries and reports can be generated from the warehouse that can help discover knowledge related to the system. It is important to note that the queries and reports created from the data warehouse cannot be generated from the individual systems. The data repository of a hospital warehouse system gathers data from all the other systems in the hospital: healthcare systems, administration systems and ancillary systems. After cleaning the data, which may include summarizing, reorganizing for easier queries, identifying and correcting erroneous information, the data is transferred to the data warehouse where queries and reports can be generated. Queries can be for operational purposes, such as “What are
our revenues and expenses from the new cardiac laboratory?" or "What is the hospital-acquired infection rate for each unit compared with their staffing level?" or can be for research, particularly for identifying patients who are eligible for research, such as "What (and how many) patients have a diagnosis of diabetes with at least one HgbA1c (hemoglobin A-1-C) of > 8 as an outpatient in the last year and have been hospitalized more than once in the past year?"

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Information systems in clinics do many of the same things that hospital systems do, but on a much smaller scale. In a clinic, these systems may be separate or they may be combined into one system. Like the hospital setting, there are systems that register patients, schedule appointments, and manage billing. There is an EHR for collecting, managing and displaying patient data. Unless the clinic is associated with a hospital/healthcare system, it will need to interface with systems outside the clinic such as pharmacies, labs and imaging services; however, it is still unusual for clinics to have a direct EHR interface. As a result, FAX machines may still be used for sending lab and imaging results;

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This slide shows a diagram of an information system at an independent clinic. Note that the light colored boxes represent parts of the clinic's system; the dark boxes are external systems. At the core of the clinic's system is the EHR, billing and registration and scheduling systems. These can be separate systems or integrated together. This central system then connects to external systems such as outside labs, outside imaging and outside pharmacies. While it is common for EHRs to be able to order medication, labs or images from outside systems, it is less common for all results to be communicated back electronically, particularly images. Instead, the outside labs/imaging will fax or mail results and reports to the clinic where they can be scanned and imported to the EHR. They may also be printed and included in the patient's paper chart (which often still exist in clinics, even those with an EHR).

It is not surprising that clinic systems are far less complex than a system at a hospital. And while there may be electronic connections to outside systems, often-times clinics still rely on fax or mail for receiving reports from outside systems.

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In summary, information systems are used in healthcare systems for managing billing, financial data, laboratory data and patient records. Data can be used to discover new knowledge by using artificial intelligence, knowledge discovery and machine learning. Expert systems build on knowledge to provide decision making assistance.

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This also concludes *Information Systems.*
In summary, information systems combine technology, people and processes to produce and use information. Institutions rely on information systems for managing data and processes, providing knowledge and for supporting communication and collaboration. New information systems are developed using a process that includes planning, analysis, design, implementation and support and security. Information systems are used extensively in healthcare.

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