Welcome to Health Management Information Systems, Clinical Decision Support Systems. This is Lecture a.

The component, Health Management Information Systems, is a “theory” component that provides an introduction to health care applications and the systems that use them, health information technology standards, health-related data structures, and enterprise architecture in health care organizations.

Lecture a will offer a definition of clinical decision support, provide some historical context surrounding clinical decision support, describe the requirements of a clinical decision support system, and discuss the relationship of clinical practice guidelines and evidence-based practice to clinical decision support systems.
Clinical Decision Support Systems (CDSS)
Learning Objectives

1. Describe the history and evolution of clinical decision support (Lecture a)
2. Describe the fundamental requirements of effective clinical decision support systems (Lecture a)
3. Discuss how clinical practice guidelines and evidence-based practice affect clinical decision support systems (Lecture a)

The objectives for this unit, **Clinical Decision Support Systems** are to:

- Describe the history and evolution of clinical decision support;
- Describe the fundamental requirements of effective clinical decision support systems;
- Discuss how clinical practice guidelines and evidence-based practice affect clinical decision support systems;
Clinical Decision Support Systems (CDSS)
Learning Objectives

4. Identify the challenges and barriers to building and using clinical decision support systems (Lecture b)
5. Discuss legal and regulatory considerations related to the distribution of clinical decision support systems (Lecture b)
6. Describe current initiatives that will impact the future and effectiveness of clinical decision support systems (Lecture b)

Additional objectives for this unit, Clinical Decision Support Systems are to:

- Identify the challenges and barriers to building and using clinical decision support systems;
- Discuss legal and regulatory considerations related to the distribution of clinical decision support systems;
- and Describe current initiatives that will impact the future and effectiveness of clinical decision support systems.
Osheroff, Pifer, & Teich (as cited in Das & Eichner, 2010) stated “CDS provides clinicians, patients, or caregivers with clinical knowledge and patient-specific information to help them make decisions that enhance patient care” (Das & Eichner, 2010, p. 4). Das & Eichner (2010) go on to explain “The patient’s information is matched to a clinical knowledge base, and patient-specific assessments or recommendations are then communicated effectively at appropriate times during patient care” (p. 4).

Musen, Shahar, and Shortliffe (2006) define a clinical decision support system as “any computer program designed to help healthcare professionals to make clinical decisions” (p. 700).

Bottom line, when one hears CDS or CDSS, think of computer-assisted clinical decision-making.
Computer-assisted clinical decision-making has been considered viable since the late 1950s when initial publications appeared. Then in the late 1960s, the Leeds Abdominal Pain System was created at the University of Leeds. The Leeds Abdominal Pain System was built based on “computer-based decision aids using Bayesian probability theory” (Musen, Shahar, & Shortliffe, 2006, p. 702).

While it is not possible to explain the theory in depth in this short course, it is important to know the theorem is based on rules of predictive probability. A clinical decision support system may use Bayesian logic in its inference engine.
Other systems considered to be key in the evolution of clinical decision support systems are MYCIN and HELP, both of which used rule-based approaches.

According to HIMSS, a rule is “A formal way of specifying a recommendation, directive, or strategy, expressed as ‘IF premise THEN conclusion’ or ‘IF condition THEN action’” (HIMSS Dictionary, 2010, p. 105).

MYCIN, which uses a rules-based methodology, is described by Musen, Shahar, & Shortliffe as “…an early exploration of methods for capturing and applying ill-structured expert knowledge to solve important medical problems” (p. 705).

HELP, an integrated clinical information system, has decision rules called “HELP sectors” encoded into it (Musen, Shahar, & Shortliffe, 2006, p. 705). Kuperman, Gardner, & Pryor, (as cited in Musen, Shahar, & Shortliffe, 2006) stated, “HELP has the ability to generate alerts when abnormalities in the patient record are noted, and its impact on the development of the field has been immense, with applications and methodologies that span nearly the full range of activities in biomedical informatics” (p. 705).

In addition to Bayesian logic and rule-based approaches, the current clinical decision support systems may use other reasoning methodologies such as neural networks or combinations of several methods.
Two Healthcare Information Technology Standards Panel (HITSP) groups convened a meeting with experts in the area of clinical decision support systems and one outcome was the image shown on this slide. As explained by Boone (2006) in his blog, clinical decision support was “…viewed as a black box, through which we have three different kinds of inputs, and several different types of outputs… The three different inputs include:

1. Algorithms, or knowledge about how to make inferences or assertions based on existing instance or world knowledge.

2. Instance data describing the specific case that is being addressed by the clinical decision support application.

3. Ontological or "world knowledge", representing facts about the world, such as what drugs interact badly, or how body parts are related, or the relationships between genes and diseases" (para. 13).

The output of information, actions, and alerts is characterized by symbols shown coming from the black box representing clinical decision support.

This image of a model is representative of the components of clinical decision support.
As the previous slide showed, a model of a clinical decision support involves certain inputs in order to arrive at an output. Berner (2009) explains the system requirements in the following way: “Common features of CDS systems that are designed to provide patient-specific guidance include the knowledge base (e.g., compiled clinical information on diagnoses, drug interactions, and guidelines), a program for combining that knowledge with patient-specific information, and a communication mechanism—in other words, a way of entering patient data (or importing it from the EMR) into the CDS application and providing relevant information (e.g., lists of possible diagnoses, drug interaction alerts, or preventive care reminders) back to the clinician” (p. 5).

Each component provides a piece that is important for clinical decision support interventions to occur. For example, clinical decision support could provide suggestions for possible diagnoses (knowledge base) that match a patient’s signs and symptoms (inference engine) and communicate this to the provider through a ranked list of diagnoses that might explain the patient’s signs and symptoms (communication mechanism).
The first system requirement is the knowledge base. A knowledge base is just what you would expect it to be, that is an automated representation of clinical knowledge.

Osheroff et al. (2006) defined clinical knowledge as “A generally applicable fact (or set of facts), best practice, guideline, logical rule, piece of reference information (such as a text article), or other element of information that is important to know for optimal data interpretation and decision-making regarding individual and population health and health care delivery” (p. 59).

The knowledge base is a collection of clinical information on such things as diagnoses, drug interactions, and evidence-based guidelines. Content for the knowledge base comes from internal as well as external sources such as specialty societies, commercial knowledge vendors, and health care organizations. Because of amount of time and expertise it takes to create content, healthcare providers usually depend on developers of clinical information systems for the knowledge base who often will obtain and incorporate commercial knowledge bases into their CDS products. For example, a number of drug knowledge bases are available in the marketplace.
The second system requirement is the inference engine. In a clinical decision support system, the inference engine combines the knowledge base with the patient's data. According to Spooner (2007), “The inference engine is the portion of the CDSS that combines the input and other data according to some logical scheme for output...One such scheme for an inference engine is the Bayesian network... A Bayesian network is a way to put Bayes' rule to work by laying out graphically which events influence the likelihood of occurrence of other events” (p. 37).

As mentioned previously, in addition to Bayesian logic, clinical decision support systems may use other reasoning methodologies such as rule-based approaches.
The final system requirement is the communication mechanism. Berner (2009) describes this component as a mechanism for entering patient data into the CDS application and providing relevant information back to the clinician.

One method for input would be importing it from the electronic medical record. Some examples of information that might be output are lists of possible diagnoses, drug-allergy alerts, duplicate testing reminder, drug interaction alerts, drug formulary guidelines, or preventive care reminders.

One of the five rights in the CDS Five Rights model is communication occurs to the right person, that is consideration of all members of the care team, such as the clinician, patient, parent or caregiver, nurse (Sirajuddin et al., 2009, p. 40).
Given the components of a CDSS, what are some expectations of its use? Berner (2009) provided examples shown in Table 5.1 of CDS interventions by target area of care.

The first row in Table 5.1 states the target area of care as preventive care with intervention examples of immunization, screening, and disease management guidelines for secondary prevention.

The second row lists diagnosis as the target area of care, where clinical decision support could provide suggestions for possible diagnoses that match a patient’s signs and symptoms.

The third row on the list is the target area planning or implementing treatment. CDS intervention could entail the display treatment guidelines for specific diagnoses, drug dosage recommendations, or alerts for drug-to-drug interactions.

The fourth row, follow-up management, is the target area of care for clinical decision support an intervention might involve information about corollary orders or reminders for drug adverse event monitoring.

The fifth row states the target area of care as hospital or provider efficiency with care plans to minimize length of stay or the presentation of order sets as examples of CDS intervention.
The sixth and final row is the target area cost reductions and improved patient convenience. Examples of CDS interventions include duplicate testing alerts and drug formulary guidelines.

Thus, CDS interventions can assist health care providers at different stages in the care process, that is, from preventive care through diagnosis and treatment, all the way to monitoring and follow-up.
Osheroff et al. (2006) describes CDS interventions as "...alerts, reminders, and order sets, as well as other techniques for knowledge delivery including reference information and education (delivered with or without context sensitivity), health/clinical protocol and workflow orchestration support, display of context-relevant data, topic-oriented documentation forms, and others" (p. 59).

Intervention types and examples as summarized by Osheroff (2009) are shown in table 5.2.

While typically several elements from these types are combined in the clinical decision support intervention, each of these intervention types will be examined independently in the next several slides. Drawing from Osheroff, Pifer, Teich, Sittig, & Jenders, (2005) AHRA provides an example of a combination of elements as "an order set might highlight—through a non-interruptive alert—an essential intervention that should routinely be ordered and provide an infobutton link to more detailed reference information that supports the clinical recommendation" (AHRQ, n.d., para 2).
Each major CDS intervention type results in certain benefits and can be further broken down into subtypes. The benefits of the documentation forms/templates intervention include the ability to “provide complete documentation for care quality/continuity, reimbursement, legal requirements; reduce omission errors by displaying items for selection; reduce commission errors by ensuring critical data—such as allergies—are captured; provide coded data for other data-driven CDS; provide prompts to acquire specific information in the format desired” (Osheroff et al., 2005).

Subtypes along with examples as summarized by Osheroff et al. (2005) are shown in table 5.3.

Row one lists the subtype of patient self-assessment forms with the example of a pre-visit questionnaire that outlines health problems and current medications.

The second row identifies the subtype of clinician patient assessment forms and an inpatient assessment as its example.

Clinician encounter documentation forms is the third subtype and a structured history and physician examination template is an example.

The fourth row refers to departmental/multidisciplinary clinical documentation forms as a subtype and emergency department
document as an example.

The fifth and final row lists data flowsheets as a subtype and the example of a health maintenance/disease management form.
The relevant data presentation intervention has several benefits. They include the ability to “optimize decision making by ensuring all pertinent data are considered and to organize complex data collections to promote understanding of overall clinical picture and to highlight needed actions” (Osheroff et al., 2005).

Subtypes and examples for this intervention as summarized by Osheroff et al. (2005) are shown in table 5.4.

Row one lists the subtype of relevant data for ordering, administration, or documentation with the example of a longitudinal display of key patient information to highlight trends and issues requiring attention.

The second row identifies the subtype of retrospective/aggregate reporting or filtering and adverse drug event tracking as its example.

Environmental parameter reporting is the third subtype and recent hospital antibiotic sensitivities is an example.

The fourth row refers to choice lists as a subtype and suggested dose choice lists, possibly modified as needed for patient’s kidney or liver function and age as an example.
The fifth and final row lists practice status display as a subtype and the example of ED tracking display.
The benefit to order/prescription creation facilitators include “promote adherence to standards of care by making the right thing the easiest to do” (Osheroff et al., 2005).

The subtypes and examples for the order/prescription creation intervention as summarized by Osheroff et al. (2005) are shown in Table 5.5.

Row one lists the subtype of single-order completers including consequent orders with the example of suggested drug and/or dose choice lists integrated into ordering function—possibly modified by patient’s kidney or liver function and age.

Order sets is the third subtype and general order sets such as an order set for hospital admission or problem-oriented ambulatory visit is an example.

The third and final row identifies tools for complex ordering as a subtype and the example of guided dose algorithms based on weight, body surface area (BSA), kidney function, etc.
The next intervention is protocol/pathway support. The benefit of this intervention is that it “Provides support for multistep care plans, pathways, and protocols that extend over time” (Osheroff et al., 2005).

As summarized by Osheroff et al. (2005), table 5.6 identifies two subtypes and examples for the protocol/pathway support intervention.

Row one lists the subtype of stepwise processing of multi-step protocol or guideline with the example of tools for monitoring and supporting inpatient clinical pathways (for example, for pneumonia admissions) and multiday/multi-cycle chemotherapy protocols in the inpatient or outpatient setting.

Support for managing clinical problems over long periods and many encounters is the second subtype and computer-assisted management algorithm for treating hyperlipidemia over many outpatient visits is an example.
"Address recognized information needs of patients and clinicians" (Osheroff et al., 2005) is a benefit of the CDS intervention type, reference information and guidance.

The subtypes and examples as summarized by Osheroff et al. (2005) are shown in table 5.7.

Row one lists the subtype of context-insensitive with the example of a general link from EMR or clinical portal to a reference program (at table of contents or general-search level).

The second row identifies the subtype of context-sensitive and link within patient-messaging application to relevant patient drug information leaflets as its example.
The final intervention is alerts and reminders. The benefits to this intervention include “provide immediate notification of errors and hazards related to new data or orders entered by clinical information system (CIS) user or the CIS itself (such as when abnormal lab result is posted) or passage of a time interval during which a critical event should occur; help enforce standards of care. Effectiveness requires careful attention to workflow, high value of information to end user, and other factors” (Osheroff et al., 2005).

The subtypes and examples for the alerts and reminders intervention as summarized by Osheroff et al. (2005) are shown in table 5.8.

The first row refers to alerts to prevent potential omission/commission errors or hazards as a subtype and drug interaction alert, for example, with drugs, pregnancy, laboratory, food as an example.

Row two lists the subtype alerts to foster best care and the example disease management such as an alert for needed therapeutic intervention based on guidelines/evidence and patient-specific factors.
This image is an example of the subtype alerts to prevent potential omission/commission errors or hazards. The screen shot depicts an example of a CDS drug warning alert. The warning indicates the patient is currently on another drug and to avoid use due to a patient’s possible allergy to cephalosporins. The user has different options to consider, including canceling or continuing with the order thereby overriding the alert.
As mentioned previously, requirements for clinical decision support include the knowledge base, inference engine, and the communication mechanism. Each component provides a piece that is essential for clinical decision support interventions to occur. Since clinical decisions are made based on the intervention, then the accuracy and reliability of the knowledge base is vitally important.

Clinical best practices and evidence-based medicine are important to the trustworthiness of the knowledge base or its rules and associations of compiled data. Osheroff et al. (2006) explain CDS has the capability of having the scientific evidence and clinical best practices be more available and helpful and “in so doing adds substantially to the value of health information technology such as EHRs and CPOE …It is only through CDS that EHRs and CPOE can achieve their full potential for improving the safety, quality and cost-effectiveness of care” (p.22).
Clinical Practice Guidelines

- Systematically developed statements
- Assist practitioners decision making about appropriate healthcare
- Specific clinical circumstances

Clinical practice guidelines are a foundational part of the knowledge base. The Quality Assurance Project (QAP), funded by the U.S. Agency for International Development, includes a glossary of useful terms. According to Marquez (2001) “Practice guidelines consist of systematically developed statements, usually based on scientific evidence and expert consensus, to assist practitioner decision making about appropriate care for a specific clinical situation” (p. 5).

A similar definition from the National Library of Medicine (NLM) defines a clinical practice guideline as “Work consisting of a set of directions or principles to assist the health care practitioner with patient care decisions about appropriate diagnostic, therapeutic, or other clinical procedures for specific clinical circumstances. Practice guidelines may be developed by government agencies at any level, institutions, organizations such as professional societies or governing boards, or by the convening of expert panels. They can provide a foundation for assessing and evaluating the quality and effectiveness of health care in terms of measuring improved health, reduction of variation in services or procedures performed, and reduction of variation in outcomes of health care delivered” (NLM, 2012).

Clinical practice guidelines are central to determining the care plan for a patient and are considered to be the preferred process for care.
As the previous slide noted, there a number of places where clinical practice guidelines can be located. For example, government agencies, institutions, professional societies, or expert panels may generate them.

Clinical practice guidelines “…can provide a foundation for assessing and evaluating the quality and effectiveness of health care in terms of measuring improved health, reduction of variation in services or procedures performed, and reduction of variation in outcomes of health care delivered. Clinical or practice guidelines usually cite references from a research study whose findings were used to support the recommendations as noted in the guideline” (Becker Medical Library, 2010, para. 2, 3)
The National Guideline Clearinghouse (NGC), a program of the Agency for Healthcare Research and Quality (AHRQ), was formed as a partnership with the American Medical Association and the American Association of Health Plans (now America’s Health Insurance Plans [AHIP]). The NGH is a public resource for evidence-based clinical practice guidelines.

The image shown is a screen shot taken from AHRQ’s National Guideline Clearinghouse. It shows a portion of the clinical practice guideline for using nontraditional risk factors in coronary heart disease risk assessment. The source of this guideline is the U.S. Preventive Services Task Force, a federally-appointed panel of independent experts. It is an example of a source for clinical practice guidelines from a government agency.
Clinical practice guidelines which are based on evidence present the strongest case for accuracy and reliability. The National Library of Medicine (NLM) defines evidence-based practice as “A way of providing health care that is guided by a thoughtful integration of the best available scientific knowledge with clinical expertise. This approach allows the practitioner to critically assess research data, clinical guidelines, and other information resources in order to correctly identify the clinical problem, apply the most high-quality intervention, and re-evaluate the outcome for future improvement” (NLM, 2012).

The practice of evidence-based medicine is supported through the provision of clinical decision support systems. As Berner (2009) emphasized, “…the quality of the information and the evidence underlying it are the major determinants of the impact of clinical decision support on patient safety and quality improvement” (p. 7).

The accuracy and reliability of the knowledge base is vitally important since clinical decisions are being made based on the intervention. Clinical best practices and evidence-based medicine are essential to the trustworthiness of the knowledge base. Through the provision of clinical decision support systems the practice of evidence-based medicine is supported.

While guidelines exist, the reality is the availability and utility of useful guideline representations and user interface issues continue as challenges in CDS deployment.
This concludes Lecture a of Clinical Decision Support Systems. This lecture defined clinical decision support, described system requirements, and explained the effects of clinical practice guidelines and evidence-based practice on CDSS.
Clinical Decision Support Systems

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Tables

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Images

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