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Medical Informatics

Lecture 1

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Lecture 5

Clinical decision support

Objectives:

- Define electronic clinical decision support (CDS)
- Enumerate the goals and potential benefits of CDS.
- Discuss organizations supporting CDS.
- Discuss CDS taxonomy, functionality and interoperability.
- List the challenges associated with CDS.
- Enumerate CDS implementation steps and lessons learned.

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Clinical decision support.pdf

CDS

Intro to CDS & CDSS

- **Clinical decision support (CDS)** provides **clinicians, staff, patients or other individuals** with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care." (The Office of the National Coordinator for Health IT (ONC)).
  -patient is involved in the decision process.
- **Clinical Decision Support System (CDSS)—Information technology** systems that support electronic CDS.
  - **Early on:** CDS was thought of only in terms of reminders & alerts.
  - **Now:** CDS can include diagnostic help, cost data (help the patient make decisions and assess her/his options), calculators (drug-drug interactions), up-to-date, etc.
  - **Vision:** CDS data to be electronic, structured (which helps move the data from system to system easily), and computable (can perform computable tasks and apply technology to it easily).

Though,we can use the Internet's potent search engines to answer questions, many organizations promote CDS as a major strategy to improve patient care and safety.
-Despite extensive online medical resources available to all members of the healthcare team, questions concerning correct diagnoses and optimal treatments still arise frequently. For that reason, many experts have strongly promoted CDS because it provide you the correct information at the right time and it being implemented with EHR is an additional positive.

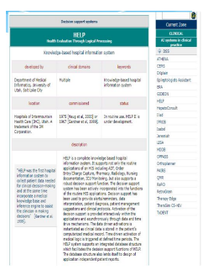
Five Rights of CDS

for CDS to be effective it must include five rights:

1. **Right Information** (high quality information from high quality article and clinical guidelines).
2. To the **Right People** (the person who is making the clinical decision - physician, patient, or other members of the healthcare team- ex: pharmacist).
3. In **Right Intervention format** (should the information appear as part of an alert, reminder, infobutton or order set?).
4. Through the **Right Channel** (should the information be available as an EHR alert, a text message,email alert, etc.?).
5. At the **Right Time.**

Historical prospective

- As early as the 1950s scientists predicted computers would aid medical decision making.
- CDS programs appeared in the 1970s and were standalone (not integrated into EHR) programs that eventually became inactive.
- You can find all of the resources: http://www.openclinical.org/aisp_help.html



-Help is a cds tool that was developed by the university of utah.In the link you will find full description of this cds tool and on the side some other cds tools.

Examples of CDS tools

CDS Tool name	Approach (technology) used	Purpose
De Dombal's system	Bayes theorem (Bayesian probability) (a theoretical or statistical approach)	Make Differential diagnosis for acute abdominal pain
Internist-1	IF-THEN statements (rule-based)	Use observations from patients to Predict diagnoses
MYCIN developed by Dr. Edward (Ted) Shortliffe and others at Stanford University.	Rule-based system	Help in Diagnosis and treatment of infections
SnapDx (Apple iOS) a free mobile app that is a diagnostic CDS for clinicians. 	Positive and negative likelihood ratios from medical literature (mathematical)	Diagnosis (App covers about 50 common medical conditions)
Isabel	Inference engine uses natural language processing and supported by 100,000 documents -Uses the free text documents that has signs and symptoms and it will generate a list of integrated coded informations. -Signs and symptoms are inputted as free text or imported from the EHR and a diagnostic checklist is generated as a standalone tool or integrated with the EHR (SNOMED-CT coded).	A Diagnosis tool

CDS Cont..

Isabel Story

- Why the name Isabel?
- Isabel is not an acronym but the name of the little girl whose illness inspired a medical tool diagnosed to help prevent misdiagnosis.
- In 1999, 3 year old Isabel Maude nearly fetally misdiagnosed by her family doctor and hospital when her chickenpox developed, undetected, into Necrotizing fasciitis and Toxic Shock Syndrome. The result of this error was two months in hospital including a month in PICU struggling to survive from multiple organ failure and cardiac arrest. Against all odds, she survived her ordeal and, despite undergoing reconstructive surgery nearly two decades later, she is now an ambitious first class honors graduate pursuing a career in London. Surviving this life-threatening illness has given her a determination to live life to the full - conquering Mount kilimanjaro is just the beginning!
- If you are interested you can read the whole story at this link: https://www.isabelhealthcare.com/about-isabel-healthcare/isabel-story

CDS Benefits & goals (Table 8.1)

- Improvement in patient safety (Medication alerts), patient care (Improved patient outcomes), & population health.
- Reduction in healthcare costs (Fewer duplicate lab tests and images).
- Management of complex clinical issues (Use of clinical practice guidelines, smart forms and order sets, Interdisciplinary sharing of information).
- Monitoring clinical details (Reminders for preventive services)
- Management of administrative complexity (managing referrals and insurance billing).
- Support clinical research (identify research subjects for clinical trials and cohort).
- Dissemination of expert knowledge (**evidence based information and education materials on hand).**

Supporting Organizations

Organizations that support CDS (click on the links for more info about the organizations):

Organization	Details
Institute of Medicine (IOM) (now named as National Academy of Medicine (NAM))	-They promoted “automated clinical information and CDS” by the use of information technologies to improve access to clinical information.
American Medical Informatics Association (AMIA)	• Developed 3 pillars of CDS in 2006: 1. Best available evidence.(information is well organized and in correct format when needed during decision making process). 2. High adoption and effective use. 3. Continuous improvement of Knowledge and CDS Methods: both CDS interventions and clinical knowledge undergo continuous improvement based on feedback, experience, and data that are easy to aggregate, assess, and apply.
Office of the National Coordinator (ONC)	• Has funded research to promote excellent CDS & sharing possibilities.

Supporting Organizations cont..

Organization	Details
Agency for Healthcare Research and Quality (AHRQ)	• Also funded multiple CDS research projects and initiatives.
HL7 (health level 7)	• Has a CDS working group and developed FHIR standards, discussed later
National Quality Forum (NQF)	○ Developed a CDS taxonomy (help with future quality measurement-CDS is evaluated based on these four components: triggers (how is the performance of the triggers?), input data, intervention, & action steps).
Leapfrog	○ They have promoted both CPOE and CDS. ○ As part of their approach they developed a CPOE Evaluation Tool that tests a hospital's EHR with multiple mock scenarios such as therapeutic duplications.
Healthcare Information Management System (HIMSS)	○ Their EMR Adoption Model rates EMRs from 1-7 (Adoption levels). ○ Full use of CDS qualifies as level 6.

Types of CDS Methodology

1- Knowledge based CDS

Knowledge based CDS = evidence based,literature based.
Non-knowledge based cds = AI,machine learning, data mining.

- **Knowledge based CDS Two Phases :**

1. Knowledge Use

Involves the following steps:

1. Trigger (eg: Physician is ordering a medication).
2. Input data (data within EHR like allergies and other medications).
3. Intervention (CDS alert).
4. Action steps (physician takes action either cancel order of continue with the order).

Figure 8.2: CDS Use Phases

2. Knowledge Management: types

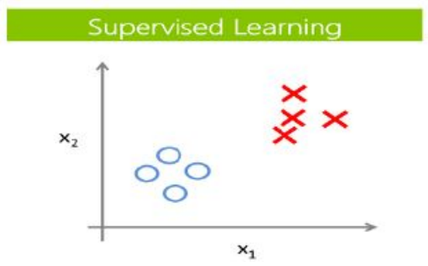
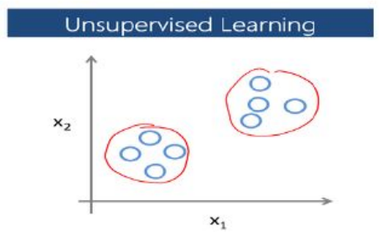
- **Knowledge Acquisition:**
expert-based knowledge or data-based knowledge. The former may come from clinical practice guidelines external to the organization and from clinical expertise from within the organization. Data-based knowledge may also come from models built on data from outside the institution (e.g., APACHE scoring) or from data mining from within the institution.
- **Knowledge Representation:**
has many forms. The choice of representation should depend on the problem at hand, the level of expertise of the knowledge engineer, the resources available, and the commitment of the institution to knowledge maintenance. The classical knowledge-based CDS consists of a knowledge base (evidence-based information), an inference engine (software to integrate the knowledge with patient-specific data) and a means to communicate the information to the end-user, such as a pop-up alert in the EHR.
- **Knowledge maintenance:**
keep knowledge up to date. This maintenance has proven challenging to most organizations.

Types of CDS Methodology cont..

2- Non-Knowledge based CDS

Is **Data mining (machine learning) algorithms.**

- The previous knowledge representation methods were based on known data so they would be labelled “knowledge based CDS”.
- When the knowledge representation is a model derived from data mining, the system is called a non-knowledge based CDS. Data mining methods may involve artificial intelligence (AI), (e.g. neural networks, machine learning) or more traditional statistical methods, like linear or logistic regression. These are data-based systems, that require the models be developed and validated prior to being used in clinical operation. An open-source program for all these methods is the WEKA environment.
- If CDS is based on data mining-related techniques it would be referred to as “non-knowledge based CDS”
- Advantages of these approaches:
  - Analyze large amount of data.
  - Discovering trends and patterns at the population level. Then, the resulting model can derive recommendations specific to the patient at hand and lie at the heart of predictive analytics.
- In data mining and machine learning we have two types:

Supervised learning	Unsupervised learning
• assumes that the user knows ahead of time what classes or categories exist., eg: this is class o and that class is x. 	• You need to analyse data to get the classes (algorithms try to group similar things together to make classes). 
• types of algorithms used: -Regression model (if the target involves continuous data ((data that can be anything numerical in a range, such as a patient’s weight)). -Classification model (gives us class , dead or alive) (if the target involves discrete ((categorical or nominal)) data ((can only be certain values, such as blood type)). • Types of algorithms used in classification: 1. Logistic regression binary (two categories-cancer recurrence, no cancer recurrence). 2. Decision Trees (can be used for the classification and the regression models). -There are two types of “decision trees” used in knowledge engineering: a. classification tree, where the attributes of an individual case (patient, population, setting) are input, and the algorithm classifies to one class or the other. b. The other type of decision tree is used in decision analysis to derive an optimal action, or event, a flowchart of action. They generally consist of decision nodes (squares), chance nodes (circles) and terminal nodes or outcomes (triangles).Probabilities are assigned to the path branches, while costs or other measures of value or preference are assigned to the outcomes. -Mostly used to inform policy, a few decision models have been implemented to provide patients real-time decision support as part of shared decision making. 3. Neural networks (input data then conclusions of the system then decision based on these conclusions): -capable of both supervised and unsupervised machine learning. -The results are dependent on a good training set, otherwise the results may not reflect a larger population.	a. Clustering (one of the most common ways to analyse large data and group them into distinct groups) (complex): -Most commonly they are grouped as a hierarchy. -applications: 1. Cluster analysis has been used to group gene sequences, for example identifying clusters of genes associated with breast cancer. 2. identified discrete groups of chronically ill patients that would benefit from care management (might help in lowering the cost). b. Association rules (IF-THEN) (build relationship between two things, if symptom then diagnosis). -have been used for “market basket analysis”, for example, if a man buys diapers, there is a 90% chance he will buy beer.

CDS

CDS standards

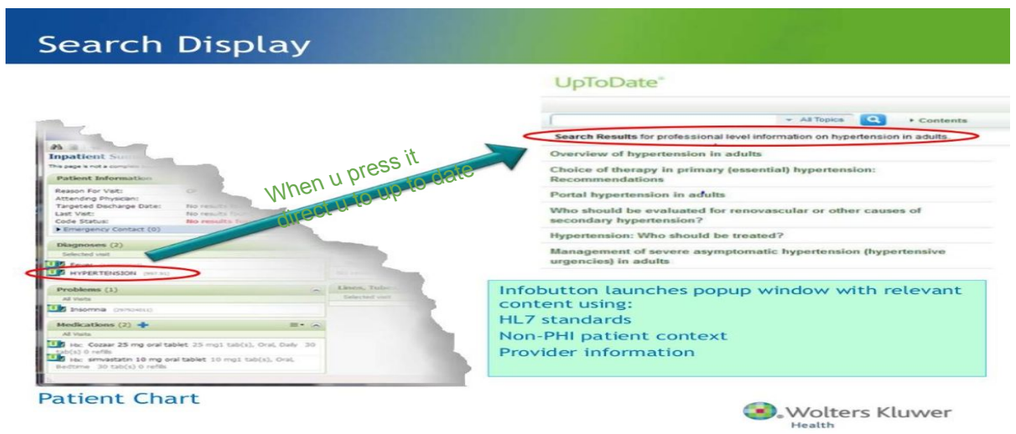
- CDS Standards= common language, important for sharing info between institutes.
- CDS developers have struggled for a long time with how to share knowledge representation with others or how to modify rules locally.
- Standards were developed to try to overcome **obstacles interoperability** (interoperability means I can move data one from one institute to another and both can understand).
- Fast Healthcare Interoperability Resources (FHIR): Developed by HL7 there is great hope that this standard will solve many Interoperability issues.
  - It is a **RESTful API (like google uses)** that uses either JSON or XML for data representation.
  - It is **data and not document centric**; so a clinician could place a http request **on EHR A** to retrieve **just a lab value from EHR B**. (because it has headings you can locate info and exchange them)

- Infobuttons: can be placed in workflow where decisions are made with recommendations (links patient's data to general information).

FHIR

http://hl7.org/fhir/2018Sep/summary.html

Infobuttons



CDS sharing

- Currently there is **no single method** for CDS knowledge can be universally shared. The approach has been to either use standards to share the knowledge or use CDS on a shared external server.
- Socratic Grid and Open CDS are open source web services platforms that support CDS.
- The FHIR standard appears to have the greatest chance for success, but it is still early in the CDS game to know.

CDS functionality

CDSSs can be classified in multiple ways:

-some doctors develop the habit of skipping disruptive alerts to get back to work, this leads to doctors missing important alerts.it is due to this that non-disruptive alerts are used more.

Knowledge
- Knowledge based.
- non-Knowledge based.

Relevance to EHR
- Internal to EHR (present within EHR).
- External to EHR
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Activation timing
- during patient encounter.
- Before patient encounter.
- After patient encounter.

Alert type
- Interruptive (disruptive):
  -The physician won't be able to do anything until he or she respond to the alert
- non-interruptive

CDS Functionality cont..

CDS functions (Taxonomy): -Taxonomy Helps to evaluate CDS system.

1.Cost

- Reminders to use generic drugs or formulary recommendations.
- Fewer duplications. (We don't do more tests that we already do, so we reduce the cost).
- Reminders about costs of drugs, lab tests, and imaging studies.
- Reduce Medicare penalties for readmissions.
- Reduce medication errors.
- Reduce malpractice claims.
- Better utilization of blood products.

2.Patient safety

- **Medication alerts.**
- Critical lab alerts.
- Ventilator support alerts.
- Improved drug ordering for warfarin and glucose.
- Infusion pump alerts.
- Risk calculation.
- Improved legibility
- Diagnostic aids.

3.Patient care

- Embedded clinical practice guidelines, order sets, and clinical pathways.
- Better chronic disease management.
- Identify gaps in recommended care.
- Immunization aids.
- ***Diagnostic aids-tools that aid in diagnosis***.
- Sepsis alerts. **(see case study infobox)**
- Antibiotic duration alerts.
- Prognostic aids.
- Patient reminders.
- Pattern recognition for images, pulmonary function tests and EKGs, blood gases, pap smear interpretation.

4.Disseminated expert knowledge

- **Use of infobuttons** for clinician and patient education (We provide the patient with resources to support him after leaving the clinic).
- Provide evidence based medicine with embedded clinical practice guidelines and order sets.

5.Managing complex clinical issues

- Reminders for preventative care for chronic diseases.
- Care management.
- Predictive modeling based on demographics, costs, and clinical parameters.

6.Managing complex administrative issues

- Decision modeling.
- Research recruitment.

CDS Functionality

Ordering Facilitators:

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1.Order sets	• Are EHR templated commercial or home grown orders that are modified to follow national practice guidelines . • For example, a patient with a suspected heart attack has orders that automatically include aspirin, oxygen, EKG, etc.
2.Therapeutic support	• include commercial products such as Theradoc and calculators for a variety of medical conditions. • clinical surveillance program that includes an Infection Control Assistant (monitors hospital acquired infections) and Pharmacy Assistant that provides drug surveillance of antibiotics and anticoagulants.
3.Smart forms	• Are templated forms, generally used for specific conditions such as diabetes. They can include simple check the boxes with evidence based recommendations. (Advantage: fast filling)(disadvantage: robot notes- not narrative or complete).
4-Alerts and reminders	• Are the classic CDS output that usually reminds clinicians about drug allergies, drug to drug interactions and preventatives medicine reminders. This is discussed in more detail in the chapter on EHRs and the chapter on patient safety. (Warning for potential problem).

Relevant information display

Hyperlink, Infobuttons, mouse over	Common methods to connect to evidence based information.
Diagnostic support	- Most diagnostic support is external and not integrated with the EHR; (e.g. Sim Consultant) . - Isabel is an example automatically pull coded signs & symptoms.
Dashboards	Can also be patient, and not population level, so they can summarize a patient's status and thereby summarize and inform the clinician about multiple patient aspects. -dashboards can include any type of patient summary, flow chart of lab results or vital signs or a disease registry. -helps the clinician track and trend common medical problems.

CDS

CDS Implementation and lessons learned

-Implementation is an iterative process.

CDS implementation	Details	Lessons learned
Project initiation	-Determine the business case/value of CDS for the organization. -Assess institute goals, value, vision, capabilities and readiness.	CDS implementation cannot be a mandate
Project planning	-Consider a SWOT analysis (strengths, weaknesses, opportunities and threats). -Be sure to follow the 5 Rights of CDS. -Educate staff and gain their input. تقسيم المتطلبات و كيف راح يكون مره مهم في هذه المرحلة.	One size does not fit all
Project Execution	-Provide adequate training and make CDS training part of EHR training. -Provide a mechanism for users' feedback in the CDS process, as well as formal support.	User feedback is critical
Project monitoring and control	-Use data from feedback, override logs, etc. to modify the system as needed.	Knowledge management & up to date content

CDS Challenges

Limitations of CDSS are the cost, needs training of health care workers, HCW start relying on machines and forget skills.

General	Exploding medical information that is complicated and evolving. Tough to write rules.
Organizational support	CDS must be supported by leadership, IT and clinical staff (collaboration of the whole team needed) . Currently, only large healthcare organizations can create robust CDSSs.
Lack of a clear business case	Evidence shows CDS helps improve processes but it is unclear it affects behavior and patient outcomes. Therefore, there may not be a strong business case to invest in CDSSs (here we can use cds taxonomy).

CDS challenges

Unintended consequences	• They concluded that there were two major UAC patterns noted: problems associated with CDS content and the presentation of information on the computer screen. Content issues were related to shifting of human roles, outdated CDS and misleading CDS. Presentation issues were related to rigidity, alert fatigue and a variety of potential errors such as incorrect auto-completes and timing issues. • Alert fatigue is perhaps the most publicized UAC related to CDSSs. • Highly complex CDS will magnify alert fatigue and the need for near constant updating of rules and algorithms. • The physician may ignore the alert either because it is wrong or appear in a wrong place or in a wrong way.
medico-legal	-Adhering to or defying alerts has legal implications. -also patient confidentiality since we are working with patient's data.
Clinical	-Must fit clinician workflow and fit the 5 rights. -We need to understand clinician workflow, for example: physician need a system to develop by a an IT. On the other hand, IT said the physicians don't use it so we need more communication.
Technical	Complex CDS requires an expert IT team.
Lack of interoperability	Must be solved for CDS to succeed.
Long term CDS benefits	Requires long term commitment and proof of benefit to be durable, it is not just an implementation, we need to follow up and evaluate for further improvement

Future trends

If the FHIR standard makes interoperability easier we may see new CDS innovations and improved adoption.

Conclusions:

- CDS could potentially assist with clinical decision making in multiple areas.
- While there is widespread support for CDS, there are a multitude of challenges.
- CDS is primarily achieved by larger healthcare systems.
- The evidence so far suggests that CDS improves patient processes and to a lesser degree clinical outcomes.

Summary

CDSS

Clinical decision support system provides clinicians, staff, patients or other individuals with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care.

Examples	• **Internist-1** : IF-THEN statement • **MYCIN**: Rule-based system • **Isabel**: natural language processing
Types	• **Knowledge based CDS:** 1- knowledge use: trigger > input data > intervention > action steps 2- knowledge management • **Non-Knowledge based CDS:** Data mining (machine learning) algorithm 1- supervised learning: regression 2- unsupervised learning: clustering
Functions	• **Patient safety:** Medication alerts • **Cost**: fewer duplication • **Patient care:** Embedded clinical practice guidelines, Diagnostic aids • **disseminated expert knowledge:** Use of infobuttons for clinician and patient education • **Managing complex clinical issues:** Reminders for preventative care for chronic diseases • **Managing complex administrative issues:** research recruitment
Functionality	**1- ordering facilitators:** • Order sets: e.g. Pt with suspected heart attack will automatically include orders of aspirin, oxygen, EKG, etc • Therapeutic support: include calculators • Smart forms: generally for specific conditions • Alters and reminders: remind about drug allergies, drug to drug interactions, and preventatives medicine reminders. **2- relevant information display:** • Hyperlink, info buttons, mouse over • Diagnostic support: e.g. ISABEL automatically pull coded signs & symptoms • Dashboards: summarizes patient status and therapy summarize
Implementation	Project initiation > project planning > project execution > project monitoring and control
Challenges	• **Organizational support:** need all team corporations include IT and clinical staff • **Lack of clear business case:** there is still doubt that if CDSS is helping the patients but it shows an effective case regarding processing • **Unintended consequence** • **Medico-legal** • **Must fit Clinical outflow and the 5 rights** • **Technical:** require expert IT team • **Lack of interoperability** • **Require long term commitment**

MCQs

1- t provides the right information to the right person in the right format through the right channel at the right point in workflow to improve health care decisions and outcomes

A- CDSS
B- PACS
C- ICD10
D- RIS

2- For CDS to be effective

A- Right Time
B- Right Place
C- Right relations
D- Right Data

3- MYCIN purpose is

A- Predict diagnoses
B- Diagnosis and treatment of infections
C- Diagnosis tool
D- Diagnosis approach

4- Provides reference information related to patient condition/diagnosis, is a functions of ?

A- CDSS
B- CPOE
C-EHR
D-the nurse

5- ……. is a form of artificial intelligence

A- EHR
B- paper health record
C-CDSS
D-research

6-……. are entered into the CDSS as part of the routine documentation process

A-free text
B-Data
C-output
D- patient safety

Answers key

1- A 2- A 3- B 4- A 5- C 6- B

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Mohammed alsayyari

Hassan alshurafa

Raghad Soaeed

Nasser Almutawa

Sarah AlQuwayz

Bader Altamimi

Sarah Almuqati

Rania almutiri

Aljohara Alshathri

Bader Alrayes

Rana Alshamrani

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Thank you all..!<3