Clinical decision support system

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COLOR CODE: Notes   Imp   Book   Golden notes   Extra

Objectives

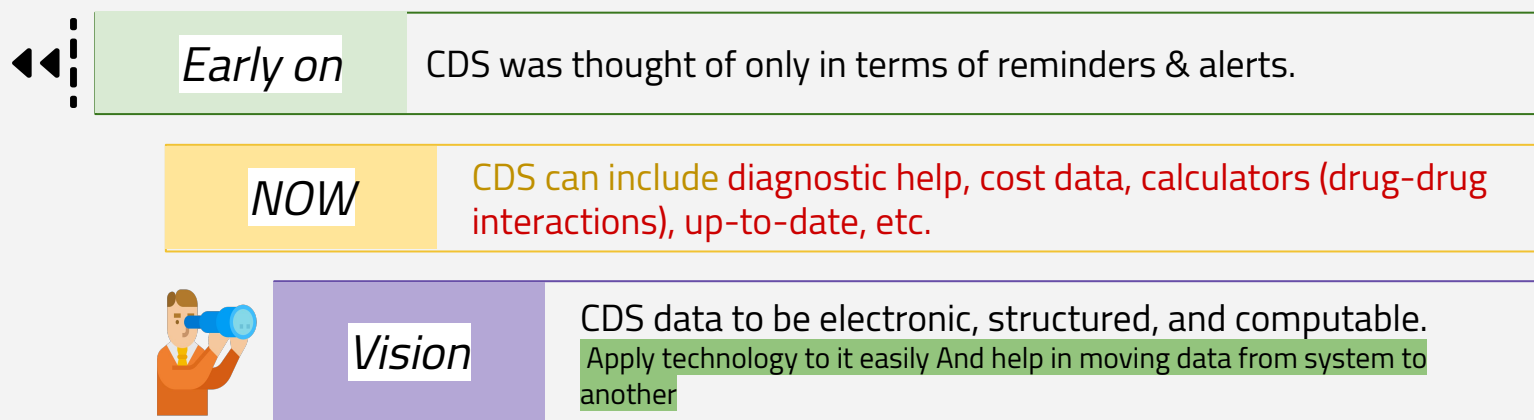After reviewing these slides, the viewer should be able to:
- Define electronic clinical decision support (CDS)
- Enumerate the goals and potential benefits of CDS
- Discuss organizations supporting CDS
- Discuss CDS taxonomy, functionality and interoperability
- List the challenges associated with CDS
- Enumerate CDS implementation steps and lessons learned
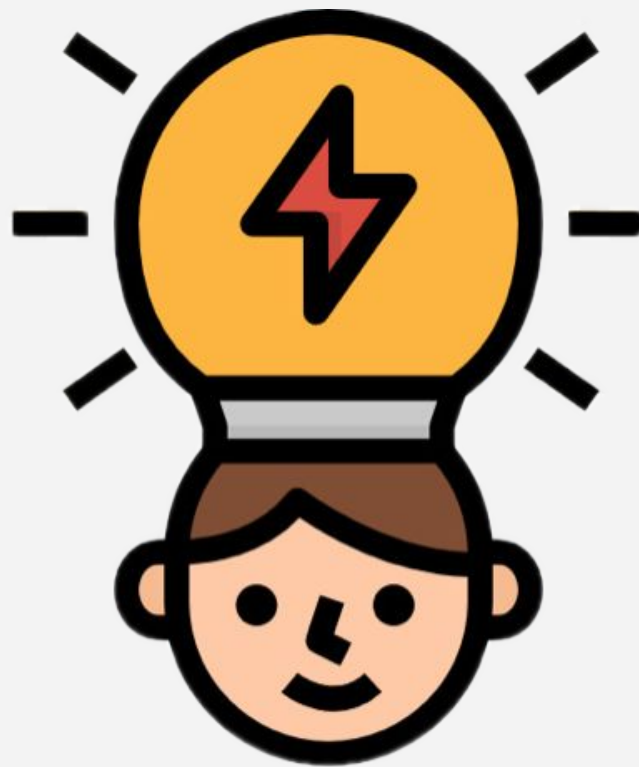
Introduction
CDS and CDSS

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))

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, calculators (drug-drug interactions), up-to-date, etc. |

| *Vision* | CDS data to be electronic, structured, and computable. Apply technology to it easily And help in moving data from system to another |

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.** The main goal: provide you the correct information at the right time.

Five rights of CDS

Right Time

Right People

Right Information

Right Channel

Right Intervention Formats
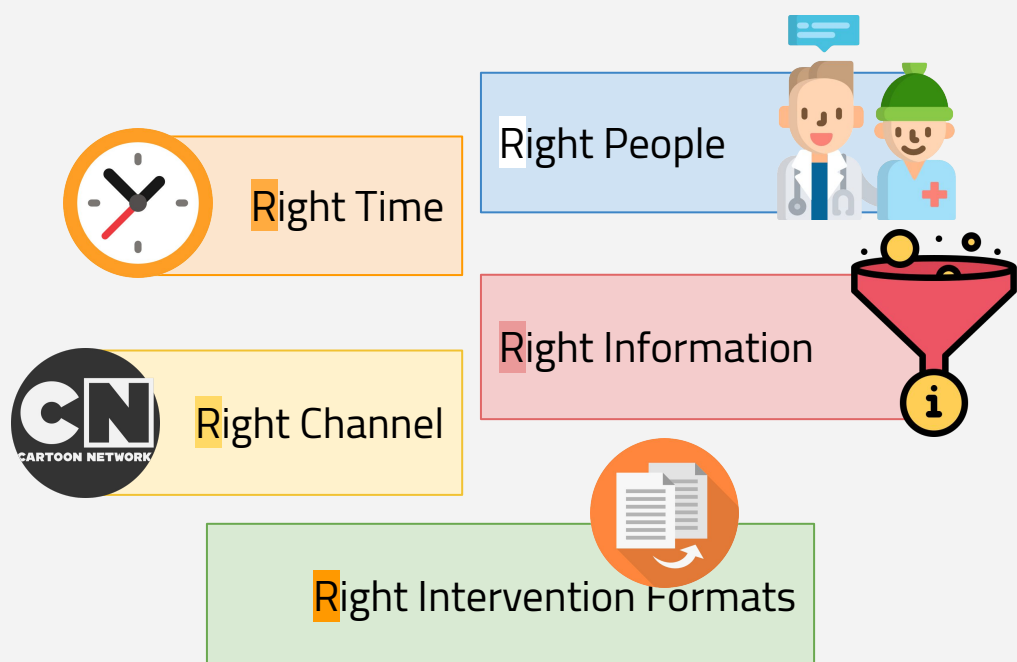
Notes:

- CDS:
  - It can support the clinical decision at the time needed
  - The patient participate in clinical decision
  - One of the goals is to improve the health outcome

- Right information derived from high quality articles & guidelines that have high level of evidence.
- To right people who make decisions in the process.
- In right intervention formats like: alerts or reminders.
- Through right channels: EHR, Email, Text message.
- At the right time.

Historical perspective

- As early as the 1950s scientists predicted computers would aid medical decision making.
- CDS programs appeared in the 1970s and were standalone programs that eventually became inactive.
- You can find all of the resources [here](#).

# Examples of CDS tools

CDS Tool name	Approach used	Purpose
De Dombal's system	Bayes theorem statistical approach	Differential diagnoses for acute abdominal pain
Internist-1	IF-THEN statements	Predict diagnoses Observation of patient and make a diagnosis
MYCIN	Rule-based system very popular tool	Diagnosis and treatment of infections
SnapDx Positive (Apple iOS)	Positive and negative likelihood ratios from medical literature provide a free App that provide diagnosis	Diagnosis (App covers about 50 common medical)
Isabel	Inference engine uses natural language processing and supported by 100,000 documents Free text document contains signs and symptoms	Diagnosis tool
DxPlain	Based on clinical findings (signs,symptoms, laboratory data) the program generated a ranked list of diagnoses related to the clinical manifestations.	Justifies the diagnoses, suggests further steps and describes atypical manifestations

Isabel Story   Read it if you're interested

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!
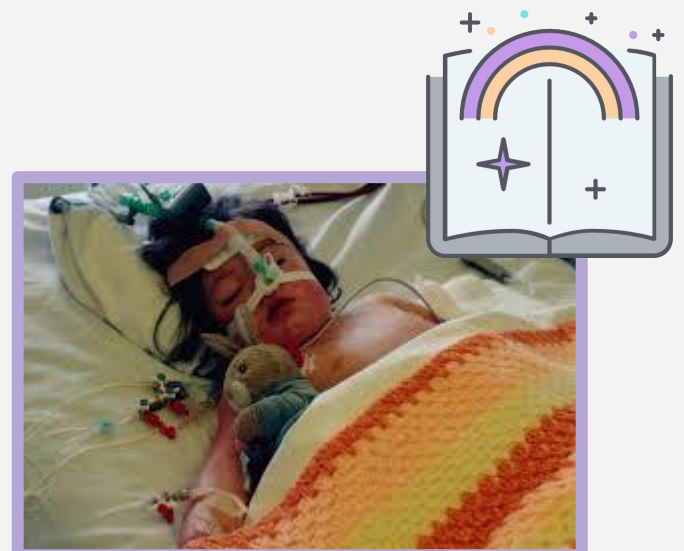
CDS Benefits and Goals
(Table 8.1)

1. Improvement in patient safety, patient care, & population health
   a. Medication alerts, improved ordering, patient outcomes, quality adjusted life years, & diagnostic accuracy
   b. Better chronic disease management, & alerts for critical lab values, drug interactions and allergies
   c. Identification of high-cost/needs patients & mass customized messaging
2. Reduction in healthcare costs
   a. By eliminating duplication of tests
   b. Increased use of generic drugs, reduced malpractice, better utilization of blood products & fewer medical errors
3. Dissemination of expert knowledge we've evidence based education & information material on hand
4. Management of complex clinical issues
   a. By following the guidelines , interdisciplinary sharing of information & case management
5. Monitoring clinical details clinical preventive services & tracking of diseases and referrals
6. Management of administrative complexity
   a. providing bills for insurance companies & transfer Pt from clinic to another
   b. Supports coding, authorization, referrals and care management
7. Support clinical research help us to select patients for RCT, cohort, & case-control studies
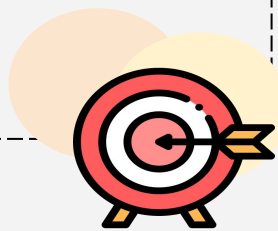
Supporting Organizations

Institute of Medicine (IOM) (now named as National Academy of Medicine (NAM)): they promoted "automated clinical information and CDS" by utilizing of technology to support access to clinical information

American Medical Informatics Association (AMIA): developed 3 pillars of CDS in 2006
1. Best available evidence. well organized, correct information,available when need it
2. High adoption and effective use.
3. Continuous improvement.
   need always to be updated and you should take care of comments that you receive for further improvement

Office of the National Coordinator (ONC): has funded research to promote excellent CDS & sharing possibilities.

Agency for Healthcare Research and Quality (AHRQ) : also funded multiple CDS research projects & initiatives.

HL7: has a CDS working group and developed FHIR standards, discussed later

National Quality Forum (NQF): developed a CDS taxonomy
(triggers, input data, intervention, & action steps look for these things to help us in evaluating)

Leapfrog: this patient safety organization have promoted both CPOE and CDS
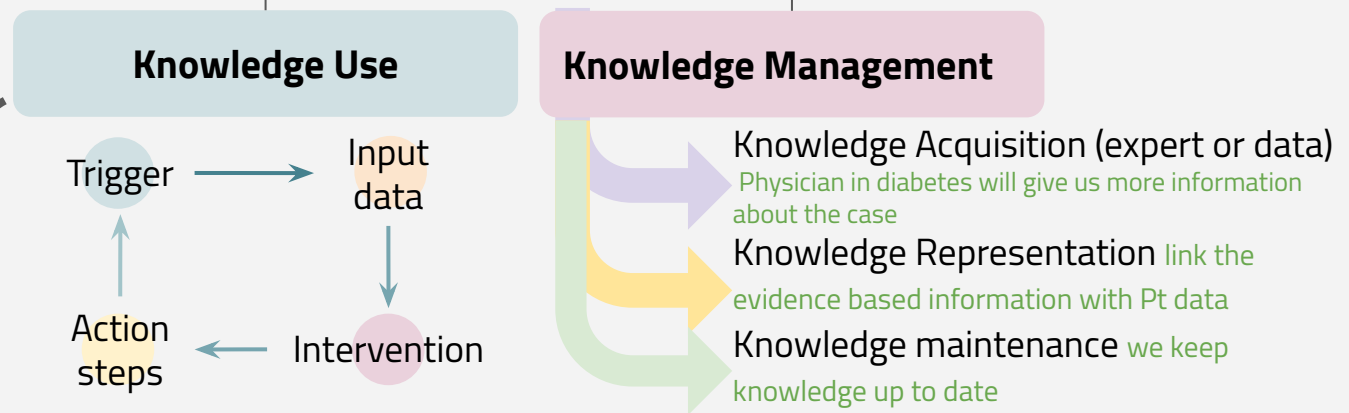
Healthcare Information Management System (HIMSS): Their EMR Adoption Model rates EMRs from 1-7. Full use of CDS qualifies as level 6 King faisal hospital is the first one in achieving level 7 in middle east

Knowledge based CDS

Knowledge based CDS Two Phases

Knowledge Use

Trigger → Input data

Action steps ← Intervention

Knowledge Management

Knowledge Acquisition (expert or data) Physician in diabetes will give us more information about the case

Knowledge Representation link the evidence based information with Pt data

Knowledge maintenance we keep knowledge up to date

Non-Knowledge based CDS

CDS Methodology
Data mining (machine learning) algorithms

- The previous knowledge representation methods were based on known data so they would be labelled "knowledge based CDS".
- If CDS is based on data mining-related techniques it would be referred to as "**non-knowledge based CDS**"
- **Advantages of these approaches**:
    a. Analyze large amount of data
    b. Discovering trends and patterns

WEKA
The University of Waikato

Supervised learning	Unsupervised learning
- Assumes that the user knows ahead of time what classes or categories exist. - Regression No. like the size of tumor - Classification died or alive? 1. Logistic regression binary (cancer recurrence, no cancer recurrence) 2. Decision Trees 3. Neural networks we've input & outcome	- Clustering one of the most common ways to analyze large data and make groups of data - Association rules (IF-THEN) Build relationship between two things,for example: observations or signs and symptoms, if it appear so I will have that diagnosis

WEKA:
It's an open source program which provide several amount of algorithms for data analysis

CDS Standards

- 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** which is the biggest obstacle, so standards help us to move or share data from the first institutional to the second and both can understand it For example: if the physician and patient speaks different language, standards helps to assess common language between them.

- **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 .I can get only one thing,so i can take patient birthday only no need to for other information

- **Infobuttons**: can be placed in workflow where decisions are made with recommendations

- Here, you can easily press the hypertension button and go quickly to UpToDate

- In UpToDate people summaries the important things to support clinical decisions

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:

Knowledge and non-knowledge based systems	Internal or external to the EHR

- internal: within the EHR
- External: links to other resources like uptodate

Activation before,during or after a patient encounter. Alerts can be interruptive or non interruptive

In interruptive The process stop until the physician response but in non-interruptive the alerts will build up and you can continue the process

CDS functionality (Taxonomy)

Taxonomy help in evaluation of CDS system

Function	Example
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
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
Patient Care	- Embedded clinical practice guidelines, order sets, and clinical pathways - Better chronic disease management - Identify gaps in recommended care - Immunization aids - Diagnostic aids - 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

Cont

Function	Example
Disseminating 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
Managing complex clinical issues	- Reminders for preventative care for chronic diseases - Care management - Predictive modeling based on demographics, costs, and clinical parameters
Managing complex administrative issues	- Decision modeling - Research recruitement مثل نظام الفواتير في المستشفيات

CDS functionality
(Ordering facilitators)

Ordering facilitators	
Order sets Special order in the EHR to customize and provide guidelines for common problems	• 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.
Therapeutic support	• include commercial products such as Theradoc and calculators for a variety of medical conditions. provide clinical surveillance like infection control assistantship to help in monitoring hospital acquired infections
Smart forms	• Are templated forms, generally used for specific conditions such as diabetes. They can include simple check the boxes with evidence based recommendations. Template that provide structural questions to fill information but it will be report information because you just fill information according to the questionnaire
Alerts and reminders Warning for potential problems	• 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.

CDS functionality
Relevant information displays

Infobuttons, hyperlinks, mouse overs

Common methods to connect to evidence based information

Like uptodate

Diagnostic support

-Most diagnostic support is external and not integrated with the EHR; (e.g. Sim Consultant)

- Isabel is an example automatically pull coded symptoms and signs

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

Provide summary of patient like vital signs

CDS Implementation and Lessons Learned

It is a process not just implementing a system

Project initiation	CDS implementation cannot be a mandate

It is hard to implement so, you have to be ready

Project planning	One size does not fit all

اذا نفعت في منظمة لا يعني أننا نستطيع تطبيقها في منظمة اخرى

Spot the analysis
Consider 5 rights
Provide educationally material

Project Execution	User feedback is critical

Training for users and get a feedback through a training process

Project monitoring and control	Knowledge management & up to date content

Keep getting a feedback
Further improvements
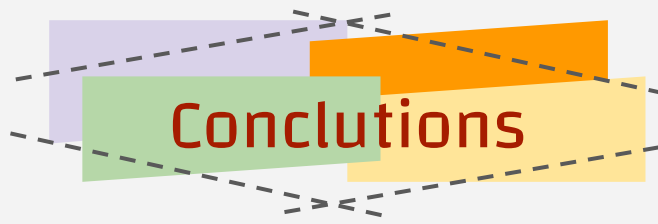
Future trends

If the FHIR standard makes interoperability easier we may see new CDS innovations and improved adoption enable liquidity of data

CDS challenges

General	Exploding medical information that is complicated and evolving. Tough to write rules we need methods more powerful to handle these large data beyond the rule system
Organizational support	CDS must be supported by leadership, IT and clinical staff. Currently, only large healthcare organizations can create robust CDSSs needs cooperation of all teams
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 we could use taxonomy here!
Unintended consequences	Alert fatigue 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 We are dealing with patients so we have legal issues like patient confidentiality and privacy
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 implantation we need to follow up and evaluate for further improvement

Conclutions

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

It is not easy for all health care system to implement CDS

The evidence so far suggests that CDS improves patient processes and to a lesser degree clinical outcomes

Examples of CDS tools

CDS Tool name	Approach used	Purpose
QMR (Quick Medical Reference)	Extensive knowledge base of diagnoses, symptoms and lab findings	A diagnostic CDDS
HELP (Health Evaluation Through Logical Processing)		It provides alerts and reminders, data interpretation, diagnostic help, management suggestions and clinical practice guidelines.
Iliad		A diagnostic CDSS and reference system for professionals
SimulConsult	Diagnostic program based on Bayesian networks.	Useful for children with genetic variants and unusual physical findings where a differential diagnosis is important.

Supporting Organizations

Office of the National Coordinator (ONC): It has 4 tasks:
- Task 1: Distill best practices for CDS design and CDS implementation, preparing resources on best practices for broad dissemination through a variety of online channels.
- Task 2: Distill best practices and standards for sharing CDS knowledge and produce an open online platform for sharing CDS knowledge artifacts among EHR vendors and/ or provider organizations.
- Task 3: Develop a "clinically important" drug- drug interaction (DDI) list, as well as a legal brief about the liability implications of using the clinically important DDI list. S
- Task 4: Develop a process that engages specialty bodies in weighing performance gaps vs. CDS opportunities to select targets for meaningful use of CDS by specialists"

Agency for Healthcare Research and Quality (AHRQ) : It has multiple CDS initiatives:
- The Clinical Decision Support Consortium (CDSC) → to assess, define, demonstrate, and evaluate best practices for knowledge management and clinical decision support in healthcare information technology at scale across multiple ambulatory care settings and EHR technology platforms."
- Guidelines into Decision Support (GLIDES) → translating CPGs into structured data for the outpatient treatment of common diseases.
- CDS eRecommendations project
- CDS Key Resources
- US Health Information Knowledgebase (USHIK) is an AHRQ initiative to support knowledge

HL7: goals to advance electronic CDS:
- Work on CDS standards for knowledge representation, such as, Infobuttons and order sets
- Work on patient centered monitoring such as alerts and reminders
- Work on population-centric monitoring and management, such as disease surveillance
- Work on representation of CPGs
- Develop a data model for clinical decision support
- Identify existing HL7 messages and triggers for CDS

Centers for Medicare and Medicaid Services (CMS) Meaningful Use Program
- Responsible for reimbursing eligible physicians and hospitals for meaningful use of certified EHRs. CMSviews clinical decision support to be integral to quality measures and the improvement of patient care

Knowledge based CDS
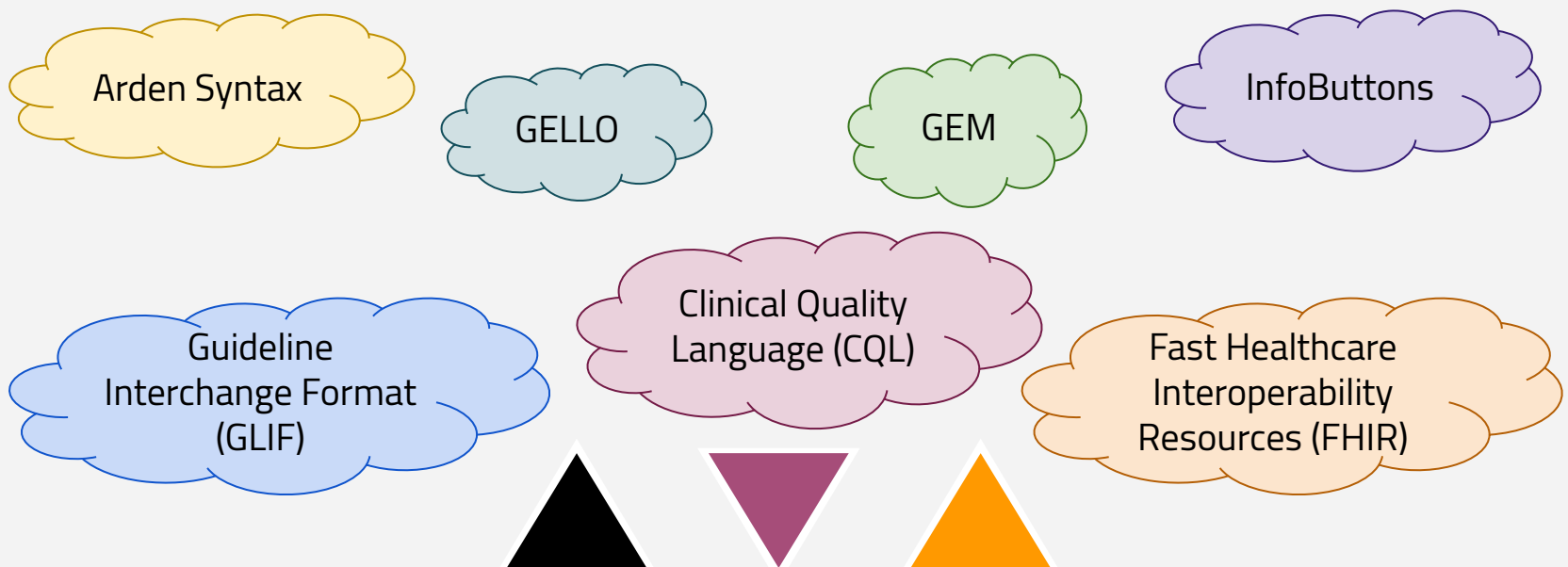
- Knowledge Use
- Knowledge Management
    a.   Knowledge Acquisition
    b.   Knowledge Representation
        i.   Configuration: represented by the choices specified by the institution, which maybe context sensitive.
            1.   Knowledge acquisition involves having the committee in charge of the clinical system
            2.   Knowledge maintenance, reviewing those choices on some frequency or as problems arise.
        ii.   Table based
            1.   Knowledge may be acquired from a vendor or CDS Committee
            2.   Knowledge maintenance involves vendor updates & periodic reviews, in light of patient quality indicators or patient-safety events.
        iii.   Rules based: consists of if-then statements, (e.g. if patient is allergic to sulfa & a sulfa drug is given, then alert will be triggered. Example: MYCIN
        iv.   Bayesian networks:
            1.   Use forms of Bayes' Theorem (conditional probabilities) to calculate the (posterior) probabilities of diseases (or other state of concern), based on the pretest probability, prevalence of each disease, P(Disease), conditioned on patient specific data (such as symptoms).
            2.   Formula: $P(Disease| Test+) = P(Test+ |Disease) \times P(Disease) \div P(Test+)$
            3.   P(Disease| Test+): positive predictive value & P(Test+|Disease): called sensitivity→ conditional probabilities
    c.   Knowledge Maintenance:
        i.   Means there is a need to keep knowledge up to date, from the level of the program through the committees in charge and to track changes and reasons.

Non-Knowledge based CDS

Data mining and predictive modeling can be categorized as supervised or unsupervised machine learning.
    1.   Supervised machine learning: The goal is to narrow the gap between observed and expected observations.
        a.   Neural Networks:
            i.   Input layer receives multiple inputs and in the hidden layer signals are processed and an output is generated to the output layer.
            ii.   Outputs are compared to the target output and training with input-output pairs is repeated until the trained output and desired target output are similar.
        b.   Logistic Regression
        c.   Decision Trees

CDS Standards

Arden Syntax

GELLO

GEM

InfoButtons

Guideline Interchange Format (GLIF)

Clinical Quality Language (CQL)

Fast Healthcare Interoperability Resources (FHIR)

Logical Steps for CDS Implementation

Logical Steps	Details
Project initiation	- Ensure clinical and non-clinical leadership are onboard and have a shared vision - Ensure CDS is synched with organizational goals, patient safety/quality measures and meaningful use objectives - Determine the business case/value of CDS for the organization - Determine feasibility from a manpower and financial standpoint and acceptance by clinicians - Ensure objectives are clear and attainable - Identify key stakeholders and assess buy-in - Understand that the CDS needs of specialists are different from primary care - Assess readiness, EHR capability and IT support - Assess the clinical information systems (CISs) involved - Assess knowledge management capabilities - Assemble the CDS team: clinical leaders, CMIO administrative and nursing leaders, managers - EHR vendor and IT experts - Identify clinical champions - Develop CDS charter
Project planning	- Consider a SWOT analysis (strengths, weaknesses, opportunities and threats) - Utilize standard planning tools such as Gantt charts and swim lanes - Develop timeline & Decide whether to build or buy CDS content - CDS committee should select CDS interventions that fit their vision - Be sure to follow the 5 Rights of CDS - Map the different processes involved with CDS and be sure they integrate with the clinician's Workflow - Determine whether you will measure structure, processes and/or outcomes - Plan the intervention: triggers, knowledge base, inference engine and communication means - Educate staff and gain their input - Design the CDS program for improvement over baseline performance in an important area for the organization. In other words, be sure you can measure outcomes and compare with baseline data - Investigate the needed CDS standards required - Follow the mandates of change management, e.g. John Kotter's Eight Step Model - Communicate goals of CDS project to all affected
Project execution	- Provide adequate training and make CDS training part of EHR training - Develop use cases - Test and retest the technology: unit, integration and user acceptance testing - Decide on incremental roll-out or "big bang" - Provide a mechanism for feedback in the CDS process, as well as formal support
Project monitoring and control	- Use data from feedback, override logs, etc. to modify the system as needed - Compare the alert and override rates with national statistics - Measure percent of alerts that accomplished desired goals - Communicate the benefits and challenges to the end-users as they arise - Use tools such as the AHRQ Health IT Evaluation ToolKit - Knowledge management maintenance; are guidelines unambiguous and up to date?

Lesson Learned

Lesson Learned	Comments
Project initiation - Healthcare organizations have competing priorities - CDS cannot come from external mandate	Ensure the organization can support a new CDS initiative. Even if CDS is intended to match meaningful use, it must be embraced by all and match organizational goals
Project planning - Customization of content and workflow is important - One size CDS does not fit all - CDS must match the 5 Rights of CDS - Make CDS as non-intrusive and non-interruptive as possible - Ideally, there should be recommendations for clinicians and patients - Interventions should include a reason for overrides - Intervention should make recommendation and not just assessment - "Do CDS with users, not to them" - EHR data must be up to date for triggers to work correctly	Customization is desirable but labor intensive and not available at smaller organizations. Specialists and primary care clinicians have different needs. Clinicians do not want to stop and speed is important.
Project execution - Feedback buttons in CDS work well - Include CDS training into EHR training - CDS must be tested for UACs and patient safety	User feedback is critical
Project monitoring and control - Knowledge management is time consuming - Be sure intervention content is up to date	There may have to be a separate knowledge management committee

Questions

Q1: "It 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"
Which one of the following describes the above statement?
A)CDSS
B)PACS.
C)ICD10.
D)RIS.

Q2: "Pop up alerts" is a feature of which of the following functional components of EHR?
A)integrated view of patient data.
B)CDSS.
C)Access to knowledge resources
D)communication and reporting tools.

Q3)Which of the following is a Drawback of CDSS?
A)flexibility
B)Legal implication
C)Faster use
D)changing relation between patient and the physician

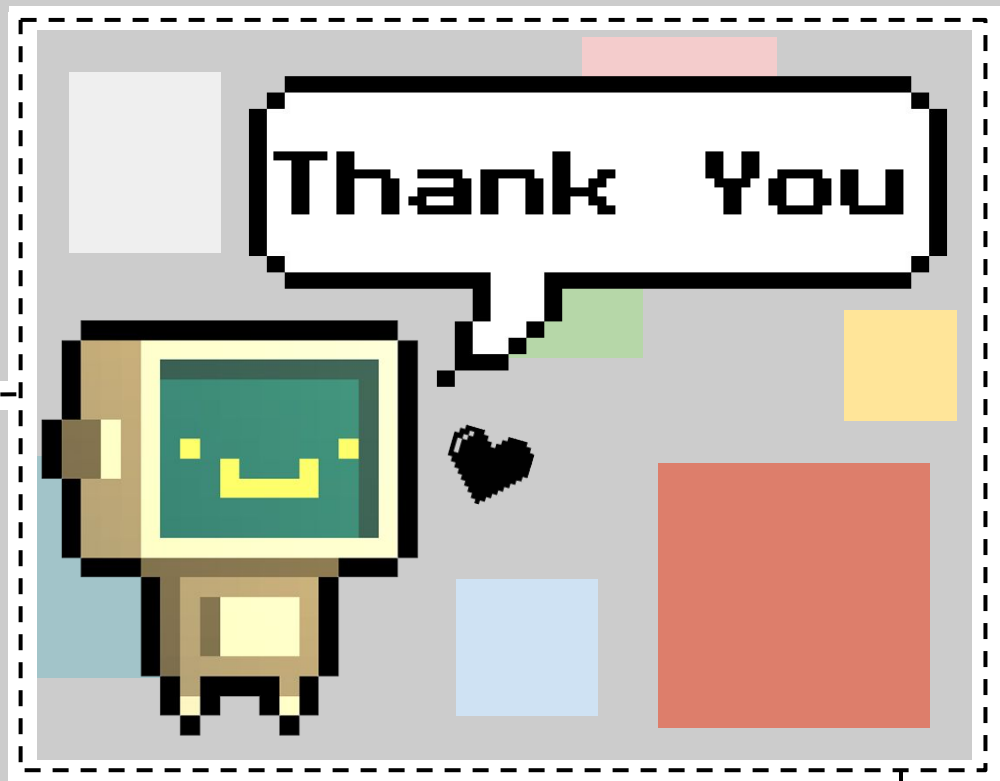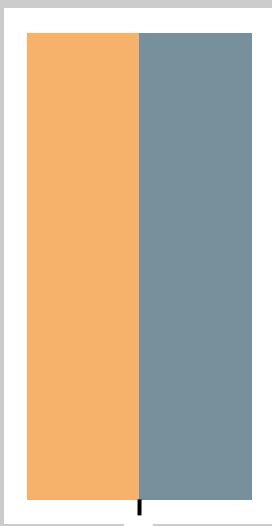**Q4)Which one of the following is an example of CDSS?**
A)MYCIN
B)PACS
C)HIPPA
D)CPOE

Q5)Why do we need expert system in CDSS?
A)Preservation of knowledge
B)Sharing of knowledge between clinician
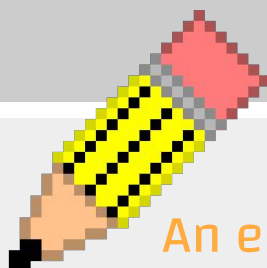C)Aid in decision making
D)Collection of data.

Which one is true?!!

1:A 2:B. 3:B 4:A. 5:C

Thank You

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