Week 5
Chapter 8: Clinical Decision Support

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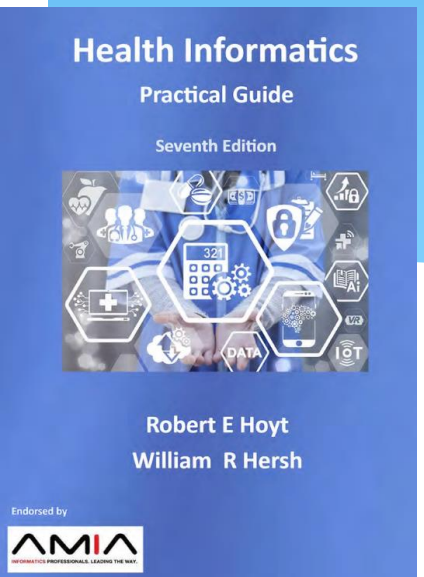

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Learning Objectives

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.

Introduction

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.

* 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**.

Five rights of CDS

Right Time

Right Channels

Right Intervention Formats

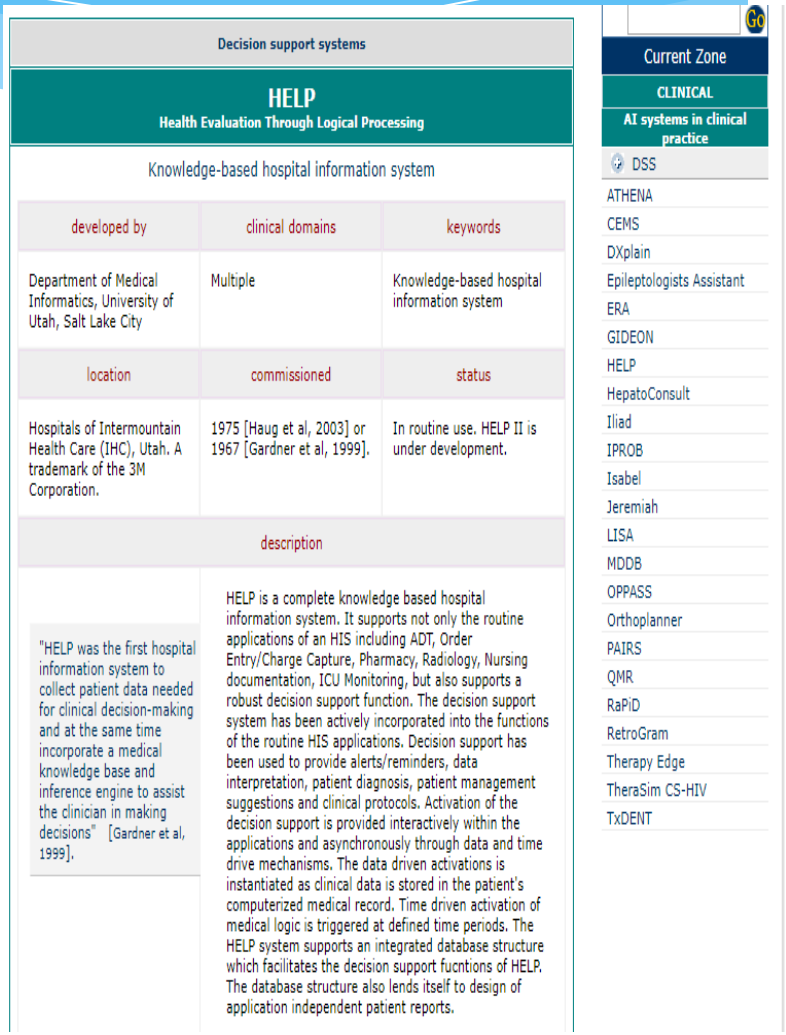
Right People

Right Information

Adopted from Dr. Suhila Sawesi, An Adjunct faculty at Indiana University – Purdue University Indianapolis (IUPUI), United States

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: http://www.openclinical.org/aisp_help.html



Decision support systems

HELP
Health Evaluation Through Logical Processing

Knowledge-based hospital information system

developed by	clinical domains	keywords
Department of Medical Informatics, University of Utah, Salt Lake City	Multiple	Knowledge-based hospital information system
location	**commissioned**	**status**
Hospitals of Intermountain Health Care (IHC), Utah. A trademark of the 3M Corporation.	1975 [Haug et al, 2003] or 1967 [Gardner et al, 1999].	In routine use. HELP II is under development.

description

"HELP was the first hospital information system to collect patient data needed for clinical decision-making and at the same time incorporate a medical knowledge base and inference engine to assist the clinician in making decisions" [Gardner et al, 1999].

HELP is a complete knowledge based hospital information system. It supports not only the routine applications of an HIS including ADT, Order Entry/Charge Capture, Pharmacy, Radiology, Nursing documentation, ICU Monitoring, but also supports a robust decision support function. The decision support system has been actively incorporated into the functions of the routine HIS applications. Decision support has been used to provide alerts/reminders, data interpretation, patient diagnosis, patient management suggestions and clinical protocols. Activation of the decision support is provided interactively within the applications and asynchronously through data and time drive mechanisms. The data driven activations is instantiated as clinical data is stored in the patient's computerized medical record. Time driven activation of medical logic is triggered at defined time periods. The HELP system supports an integrated database structure which facilitates the decision support fucntions of HELP. The database structure also lends itself to design of application independent patient reports.

Current Zone

CLINICAL

AI systems in clinical practice

DSS

ATHENA
CEMS
DXplain
Epileptologists Assistant
ERA
GIDEON
HELP
HepatoConsult
Iliad
IPROB
Isabel
Jeremiah
LISA
MDDB
OPPASS
Orthoplanner
PAIRS
QMR
RaPiD
RetroGram
Therapy Edge
TheraSim CS-HIV
TxDENT

Examples of CDS tools

CDS Tool name	Approach used	Purpose
De Dombal's system	Bayes theorem	Differential diagnoses for acute abdominal pain
Internist-1	IF-THEN statements	Predict diagnoses
MYCIN	Rule-based system	Diagnosis and treatment of infections
SnapDx (Apple iOS) 	Positive and negative likelihood ratios from medical literature	Diagnosis (App covers about 50 common medical)
Isabel	Inference engine uses natural language processing and supported by 100,000 documents	Diagnosis tool

Isabel Story

https://www.isabelhealthcare.com/about-isabel-healthcare/isabel-story

Why the name Isabel?

Isabel is not an acronym but the name of the little girl whose illness inspired a medical tool designed to help prevent misdiagnosis.

In 1999, 3 year old Isabel Maude was nearly fatally 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)

* Improvement in patient safety, patient care, & population health
* Reduction in healthcare costs
* Dissemination of expert knowledge
* Management of complex clinical issues
* Monitoring clinical details
* Management of administrative complexity
* Support clinical research

Supporting Organizations

* **Institute of Medicine (IOM) (now named as National Academy of Medicine (NAM)):** they promoted "automated clinical information and CDS"
* **American Medical Informatics Association (AMIA):** developed 3 pillars of CDS in 2006—**best available evidence, high adoption and effective use** and **continuous improvement.**
* **Office of the National Coordinator (ONC) :** has funded research to promote excellent CDS and sharing possibilities.
* **Agency for Healthcare Research and Quality (AHRQ) :** also funded multiple CDS research projects and initiatives.

Supporting Organizations

* **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)
* **Leapfrog:** they 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

CDS Methodology

Knowledge based CDS

Knowledge based CDS Two Phases

Knowledge Use

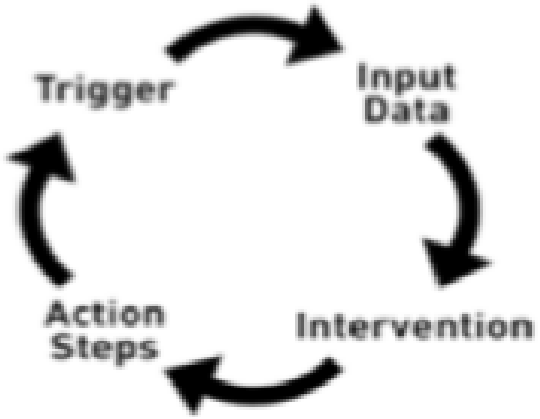


Figure 8.2: CDS Use Phases

Knowledge Management

* Knowledge Acquisition (expert or data)
* Knowledge Representation
* Knowledge maintenance

CDS Methodology

Non-Knowledge based CDS

CDS Methodology
Data mining (machine learning) algorithms

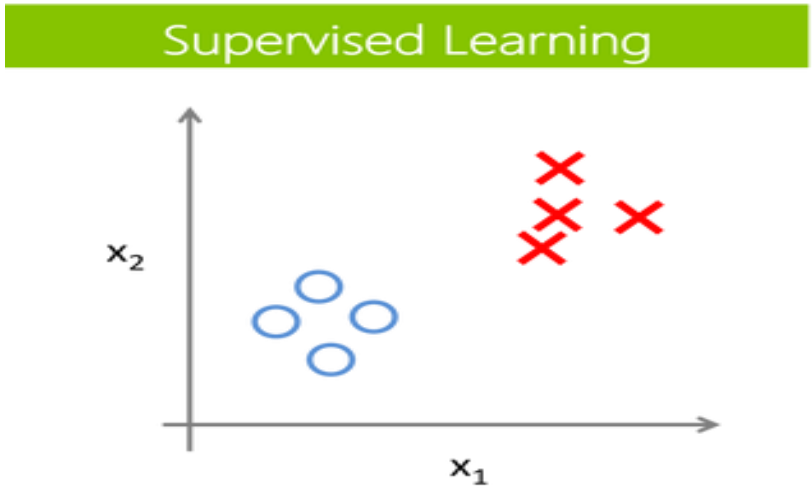
* The previous knowledge representation methods were based on known data so they would be labelled "knowledge based CDS".

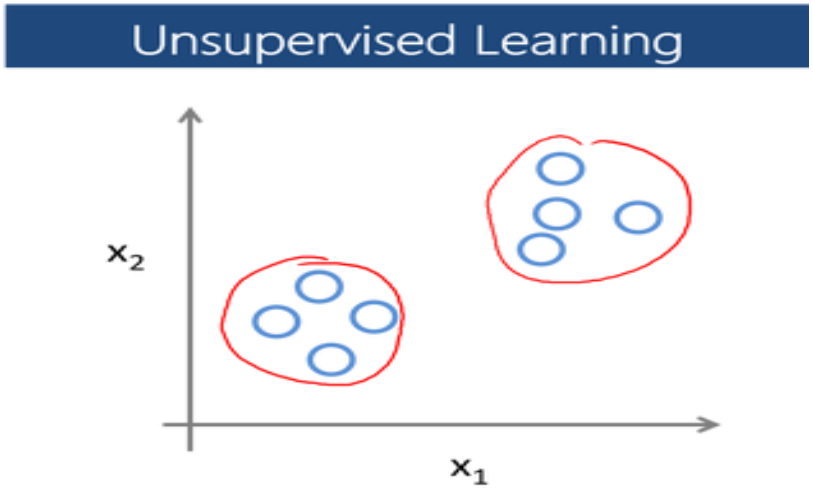
* If CDS is based on data mining-related techniques it would be referred to as **"non-knowledge based CDS"**

* **Advantages of these approaches:**

1. Analyze large amount of data
2. Discovering trends and patterns

CDS Methodology
Data mining (machine learning) algorithms





Supervised	Unsupervised
• Regression • Classification 1. Logistic regression binary (cancer recurrence, no cancer recurrence). 2. Decision Trees 3. Neural networks	• Clustering • Association rules (IF-THEN)

Source for the figure: Machine Learning: Supervised Vs Unsupervised Learning [https://lakshaysuri.wordpress.com/2017/03/19/machine-learning-supervised-vs-unsupervised-learning/]

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

CDS Standards

* **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.

```
<Patient xmlns="http://hl7.org/fhir">
  <id value="glossy"/>
  <meta>
    <lastUpdated value="2014-11-13T11:41:00+11:00"/>
  </meta>
  <text>
    <status value="generated"/>
    <div xmlns="http://www.w3.org/1999/xhtml">
      <p>Henry Levin the 7th</p>
      <p>MRN: 123456. Male, 24-Sept 1932</p>
    </div>
  </text>
  <extension url="http://example.org/StructureDefinition/trials">
    <valueCode value="renal"/>
  </extension>
  <identifier>
    <use value="usual"/>
    <type>
      <coding>
        <system value="http://hl7.org/fhir/v2/0203"/>
        <code value="MR"/>
      </coding>
    </type>
    <system value="http://www.goodhealth.org/identifiers/mrn"/>
    <value value="123456"/>
  </identifier>
  <active value="true"/>
  <name>
    <family value="Levin"/>
    <given value="Henry"/>
    <suffix value="The 7th"/>
  </name>
  <gender value="male"/>
  <birthDate value="1932-09-24"/>
  <careProvider>
    <reference value="Organization/2"/>
    <display value="Good Health Clinic"/>
  </careProvider>
</Patient>
```

Resource Identity & Metadata

Human Readable Summary

Extension with URL to definition

Standard Data:
- MRN
- Name
- Gender
- Birth Date
- Provider

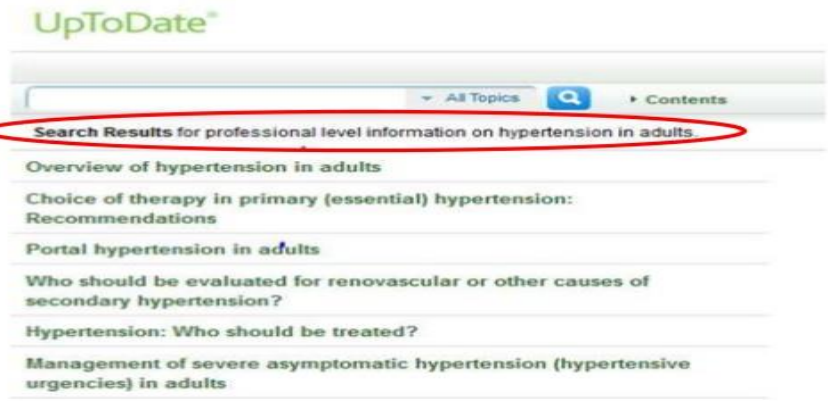
http://hl7.org/fhir/2018Sep/summary.html

CDS Standards

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

Search Display

Patient Chart



Infobutton launches popup window with relevant content using:
HL7 standards
Non-PHI patient context
Provider information

Wolters Kluwer Health

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

CDS Functionality (Taxonomy)

Function	Examples
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 • Reminders about costs of drugs, lab tests and imaging studies • Reduce Medicare penalties for readmissions • Reduced medication errors • Reduced malpractice claims • Better utilization of blood products

CDS Functionality (Function and Examples cont.)

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
Disseminating Expert Knowledge	• Use of infobuttons for clinician and patient education • Provide evidence based medicine with embedded clinical practice guidelines and order sets
Managing Complex Clinical Issues	• Reminders for preventive care for chronic diseases • Care management • Predictive modeling based on demographics, cost, and clinical parameters
Managing Complex Administrative Issues	• Decision modeling • Research recruitment

CDS Functionality (Ordering facilitators)

* **Ordering facilitators:**
  * **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.

  * **Therapeutic support** include commercial products such as Theradoc and calculators for a variety of medical conditions

CDS Functionality (Ordering facilitators)

* **Order facilitators (cont.)**
  * **Smart forms** are templated forms, generally used for specific conditions such as diabetes. They can include simple check the boxes with evidence based recommendations
  * **Alerts and reminders** are the classic CDS output that usually reminds clinicians about drug allergies, drug to drug interactions and preventive medicine reminders. This is discussed in more detail in the chapter on EHRs and the chapter on patient safety

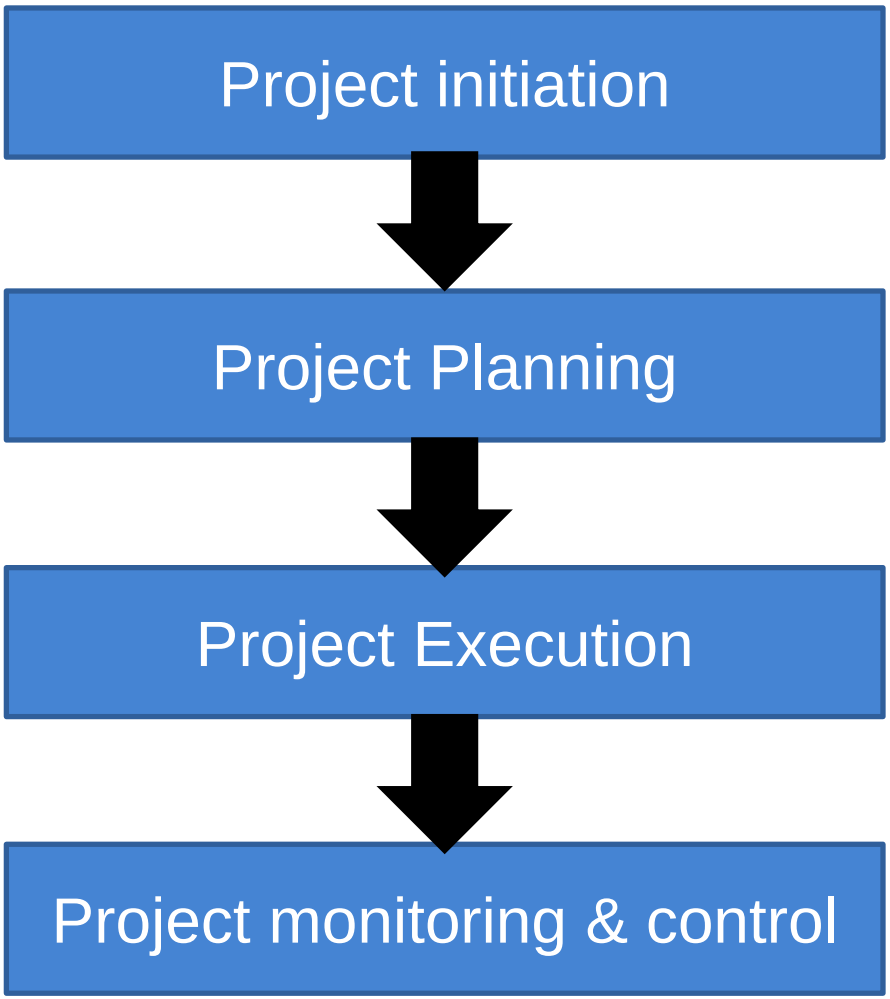
CDS Functionality

Source: https://confluence.ihtsdotools.org/display/DOCCDS/Decision+Support+with+SNOMED+CT

CDS Functionality

* **Relevant information displays**
  * **Infobuttons, hyperlinks, mouse overs:** common methods to connect to evidence based information
  * **Diagnostic support:**
    * Most diagnostic support is external and not integrated with the EHR; (e.g. SimulConsult)
    * Isabel is an example automatically pull coded symptom 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

CDS implementation & lessons learned



CDS implementation cannot be a mandate

One size does not fit all

User feedback is critical

Knowledge management & up to date content

CDS Challenges

* **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. Currently, only large healthcare organizations can create robust CDSSs

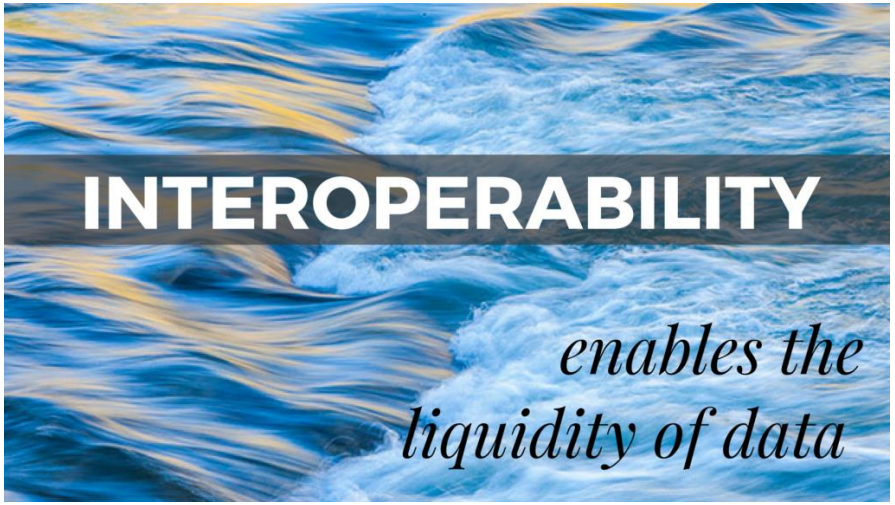
* **Lack of a clear business case:** evidence shows CDS helps improve processes but it is unclear if it affects behavior and patient outcomes. Therefore, there may not be a strong business case to invest in CDSSs

CDS Challenges

* **Unintended consequences:** alert fatigue
* **Medico-legal:** adhering to or defying alerts has legal implications.
* **Clinical:** must fit clinician workflow and fit the 5 Rights
* **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

Future Trends

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



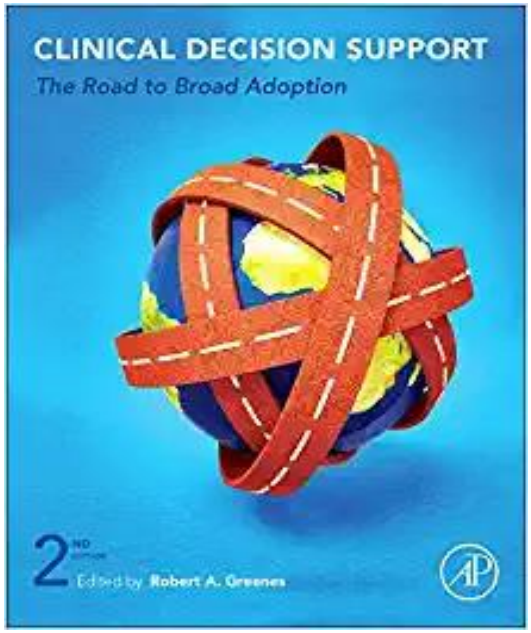
https://healthstandards.com/blog/2017/04/20/data-liquidity-interoperability/

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

A CDS book

Greenes, Robert A., ed. Clinical decision support: the road to broad adoption. Academic Press, 2014.



Thanks

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