

# CDSS

## Clinical Decision Support System

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# Management Information Systems

## Chapter 12 Enhancing Decision Making Systems for Decision Support

- **What have you learned so far?**
  - Health Information Systems
  - Electronic Health Record
  - Medical Error and how to overcome ME

### **Functions of Health Information Technology:**

- Improve Clinical Outcomes/ Enhance Patient Care
- Efficiency and Effectiveness
- To improve decision making



# Star Trek & Diagnostic Device



# Futuristic ....

- \* In *Star Trek*- point diagnostic device to patients and device determine
  - \* What is the problem ?
  - \* How serious damage is?
- \* In *Star Trek*- Diagnostic device is the “Clinical Decision Support”
- \* Societal Concerns
  - \* Can computers replace doctors in making decisions?
  - \* What kinds of decisions can computers make?
  - \* How good will computers be?
  - \* What will the effects be on the practice of medicine, on medical education and on relationship among colleagues or between physicians and patients?

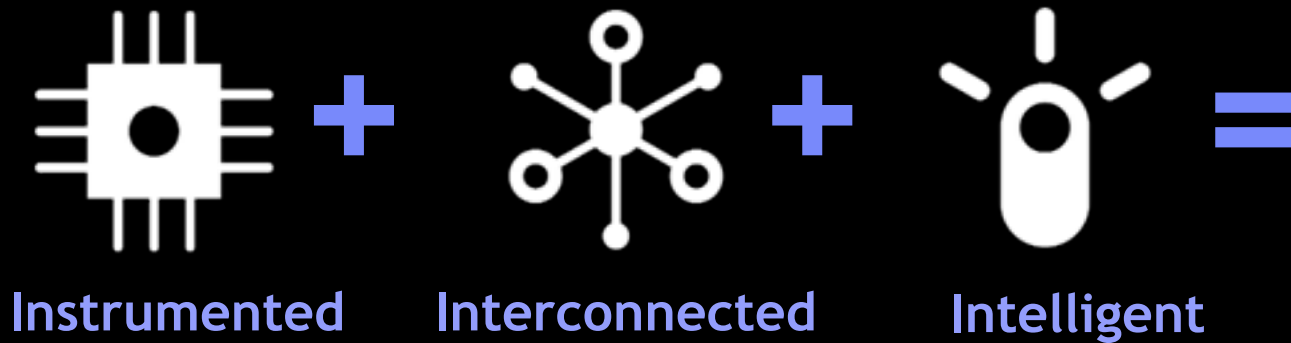


On February 14, 2011, IBM Watson changed history introducing a system that rivaled a human's ability to answer questions posed in natural language with speed, accuracy and confidence.

- Watson Wins!
- Largest Jeopardy! in 5 years
  - 34.5M Jeopardy! Viewers
  - 1.3B+ Impressions
- Over 10,000 Media Stories
- 11,000 attend watch events
- 2.5M+ Videos Views (top 10 only) 
- 10,897 Twitter 
- 23,647 Facebook Fan 




# The World is Getting Smarter



An opportunity to think and act in new ways—  
economically, socially and technically.


# Healthcare Industry is beset with some of the most complex information challenges we collectively face


 Medical information is doubling every 5 years, much of which is unstructured



**1 in 5**

diagnosis that are estimated to be inaccurate or incomplete


 81% of physicians report spending 5 hours or less per month reading medical journals



**1.5 million**

errors in the way medications are prescribed, delivered and taken in the U.S. every year



**44,000 -98,000**

# of Americans who die each year from preventable medical errors in hospitals

“Medicine has become too complex (and only) about 20 percent of the knowledge clinicians use today is evidence-based.”

Steven Shapiro, Chief Medical and Scientific Officer, UPMC

A smarter health system improves visibility and collaboration across all health system participants making best use of resources to prevent and treat diseases, reduce overall healthcare costs, and keep people healthy.



*Capture accurate, real-time information from devices & systems*

*Enable seamless information sharing across groups*

*Use advanced analytics to improve research, diagnosis and treatment*



# Why is Watson Technology ideal for Healthcare?

Understands natural language questions



What condition has red eye, pain, inflammation, blurred vision, floating spots and sensitivity to light?

Analyzes large volumes of unstructured data



Physician Notes, Medical Journals, Clinical Trials, Pathology Results, Blogs, Wikipedia

Generates and evaluates hypothesis



	<u>Possible Diagnosis</u>	<u>Confidence</u>
Uveitis		91%
Iritis		48%
Keratitis		29%

Presents responses with confidence



Family History, Patient Interview, Physical Exam, Current Medications

Supports iterative dialogue to refine results



Learns from results over time



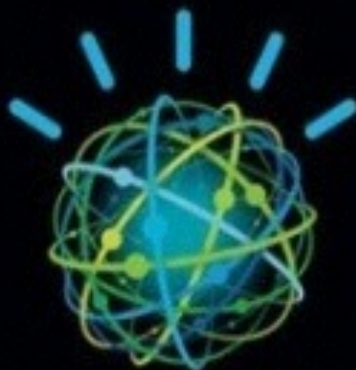
What actions were taken? What treatments were prescribed? What was the outcome?

# IBM and WellPoint are working together to put Watson to work in healthcare



**WellPoint**

Serving 1 in 9 insured Americans



**IBM Watson**



Leverage medical records

**TO**

diagnose and identify treatment options

**TO**

enhance the quality of medical care delivered

"Imagine having the ability within three seconds to look through all of that (medical) information....at the moment you're caring for that patient."

Dr. Sam Nussbaum, WellPoint's Chief Medical Officer, WellPoint

# Putting the pieces together at point of impact can be life changing

A 58-year-old woman presented to her primary care physician after several days of **dizziness, anorexia, dry mouth, increased thirst, and frequent urination**. She had also had a **fever** and reported that **food would "get stuck" when she was swallowing**. She reported no **pain** in her abdomen, back, or flank and no **cough, shortness of breath, diarrhea, or dysuria**. Her family history included **oral and bladder cancer** in her mother, **Graves' disease** in two sisters, **hemochromatosis** in one sister, and **idiopathic thrombocytopenic purpura** in one sister. Her history was notable for **cutaneous lupus, hyperlipidemia, osteoporosis, frequent urinary tract infections, three uncomplicated cesarean sections, a left oophorectomy for a benign cyst, and primary hypothyroidism**, which had been diagnosed a year earlier. Her medications were **levothyroxine, hydroxychloroquine, pravastatin, and alendronate**. A **urine dipstick was positive for leukocyte esterase and nitrites**. The patient was given a prescription for **ciprofloxacin** for a urinary tract infection and was advised to drink plenty of fluids. On a follow-up visit with her physician 3 days later, her fever had resolved, but she reported continued weakness and dizziness despite drinking a lot of fluids. Her **supine blood pressure was 120/80 mm Hg**, and her pulse was **88 beats per minute**; on standing, her **systolic blood pressure was 84 mm Hg**, and her pulse was **92 beats per minute**. A urine specimen obtained at her initial presentation had been cultured and **grew more than 100,000 colonies of Escherichia coli**, which is sensitive to ciprofloxacin.

**Symptoms**  
 difficulty swallowing  
 fever  
 dry mouth  
 thirst  
 anorexia  
 frequent urination  
 dizziness  
 no abdominal pain  
 no back pain  
 no cough  
 no diarrhea

**Family History**  
 Oral cancer  
 Bladder cancer  
 Hemochromatosis  
 Purpura  
 Graves' Disease (Thyroid Autoimmune)

**Patient History**  
 cutaneous lupus  
 osteoporosis  
 hyperlipidemia  
 frequent UTI  
 hypothyroidism

**Medications**  
 Alendronate  
 pravastatin  
 levothyroxine  
 hydroxychloroquine

**Findings**  
 urine dipstick:  
 leukocyte esterase  
 supine 120/80 mm HG  
 heart rate: 88 bpm  
 urine culture: E. Coli

## Diagnosis Models

Diagnosis Models	Fam. History	Pat. History	Medications	Findings	Confidence
Renal failure	Low	Low	Low	Low	Low
UTI	Low	High	Low	High	High
Diabetes	Low	Low	Low	Low	Low
Influenza	Low	Low	Low	Low	Low
hypokalemia	Low	Low	Low	Low	Low
Esophagitis	Low	Low	Low	Low	Low

- Extract Patient History
- **Most Confident Diagnosis: Diabetes**
- Extract Medications
- Use database of drug side-effects
- Together, multiple diagnoses may best explain symptoms
- Extract Findings: Confirms that UTI was present

# Clinical Decision Support System (CDSS)

## \* Definition:

*Provide clinicians or patients with computer-generated clinical knowledge and patient-related information, intelligently filtered or presented at appropriate times, to enhance patient care” [1]*



# Elements of CDS [1]

## \* Knowledge

- \* Provide evidence to meet physician information needs
- \* Meta-analysis of Randomized Controlled trials as evidences

## \* Patient-specific Information

- \* Medication List
- \* Problem Lists
- \* Lab results and other clinical data



# Elements of CDS [1]

- \* Filtered

- \* Gathering and presenting pertinent data

- \* Presented at appropriate time

- \* Provider able and ready to act on the information

- \* Enhance Patient Care

- \* Error prevention
- \* Quality improvement
- \* Lab results and other clinical data



# MYCIN [2]

- \* Gives ADVICE to clinicians
- \* Used Artificial Intelligence
- \* Production Rules- knowledge gathered from discussions among experts

Example:

Rule 507

Comprised of conditional statement (IF-THEN)



# Decision Making in Medicine [2]

## \* Uncertainty

- \* What is the diagnosis?
- \* What should the intervention be?
- \* What is the latest research that gives evidence the intervention really works?

### Examples:

- \* Should John get another chemotherapy?
  - \* Should Mr. James undergo a third operation?
  - \* Should Mrs. Blackwood be given hepatitis B vaccination as an intervention?
- 
- \* To ensure specificity and sensitivity





# Sensitivity & Specificity- Wikipedia

		Condition (as determined by "Gold standard")		
		Condition Positive	Condition Negative	
Test Outcome	Test Outcome Positive	<b>True Positive</b>	<b>False Positive</b> (Type I error)	Positive predictive value = $\frac{\Sigma \text{ True Positive}}{\Sigma \text{ Test Outcome Positive}}$
	Test Outcome Negative	<b>False Negative</b> (Type II error)	<b>True Negative</b>	Negative predictive value = $\frac{\Sigma \text{ True Negative}}{\Sigma \text{ Test Outcome Negative}}$
		<b>Sensitivity =</b> $\frac{\Sigma \text{ True Positive}}{\Sigma \text{ Condition Positive}}$	<b>Specificity =</b> $\frac{\Sigma \text{ True Negative}}{\Sigma \text{ Condition Negative}}$	



# Sensitivity & Specificity- Wikipedia

		Patients with <b>bowel cancer</b> (as confirmed on <b>endoscopy</b> )		
		Condition Positive	Condition Negative	
<b>Fecal Occult Blood Screen Test Outcome</b>	Test Outcome Positive	<b>True Positive</b> (TP) = 20	<b>False Positive</b> (FP) = 180	Positive predictive value = TP / (TP + FP) = 20 / (20 + 180) = <b>10%</b>
	Test Outcome Negative	<b>False Negative</b> (FN) = 10	<b>True Negative</b> (TN) = 1820	Negative predictive value = TN / (FN + TN) = 1820 / (10 + 1820) ≈ <b>99.5%</b>
		<b>Sensitivity</b> = TP / (TP + FN) = 20 / (20 + 10) ≈ <b>67%</b>	<b>Specificity</b> = TN / (FP + TN) = 1820 / (180 + 1820) = <b>91%</b>	



# Why CDS?[1]

## 1. Questions

- \* Unanswered Questions
- \* Some doubts



# Why CDS?[1]

## 2. Information

- \* Unmet information need
- \* Cannot process information
- \* Lack of time
- \* Unsatisfied information need
- \* Unrecognized information need



# Why CDS? [1]

## 3. Inquiry

- \* Needs time
- \* Resource Intensive (Evidence, Literature, Knowledge)

Solutions are needed.... CDS can help provide ALERTS and REMINDERS

- \* To avoid errors and increase patient safety- new knowledge discovery - average 17 years to take evidence into clinical practice
- \* CDS embedded in EMR to improve patient safety and reduce medical error



# Searching for evidence

*Examples of resources:*

**Computerised decision support systems**

**Evidence-based clinical practice guidelines  
Evidence-based textbooks**

**DARE; [health-evidence.ca](http://health-evidence.ca)  
Evidence-based abstraction journals**

**Systematic reviews  
(eg, *Cochrane Library*)**

**Evidence-based abstraction journals**

**Original articles published in journals**

**Systems**

**Summaries**

**Synopses of Syntheses**

**Syntheses**

**Synopses of Studies**

**Studies**

Case report, Case series, Case-Control, Cohort, Randomized Trial

DiCenso A, Bayley L, Haynes RB. Accessing preappraised evidence: fine-tuning the 5S model into a 6S model. ACP Journal Club, 2009

# Clinical Decision Support System (CDSS) [3]

- \* CDSS in Patient Monitoring Systems
  - \* Example: ECG that gives out warning
- \* CDSS embed in Electronic Medical Record (EMR) and Computerized Patient Order Entry (CPOE)
  - \* Example: Send reminders/warnings in test results, drug-drug interaction, dosage errors etc.
- \* Formulating Diagnosis
- \* Formulating Treatment



# Roles of Computer in Decision Support or Clinical Decision Support (CDS)

## CDSS in Prescription [4]

- \* Guiding prescribing practices
- \* Flagging adverse drug reactions
- \* Identify duplication of therapy





# Constructing DSS[1]

- \* Elicitation of Medical Knowledge
- \* Reasoning and Representation
- \* Validation of System Performance
- \* Integration of CDSS Tools



# Types of CDSS [1]

## 1) Documentation Tool

- \* Provide complete documentation
- \* Well-designed order form
- \* Required fields & Proper information
- \* Reduce error of Omission by providing selection
- \* Provide **coded data** for CDSS



# Types of CDSS [1]

Types	Sub-types	Examples
<b>1. Documentation Tool</b>		
	<b>1.1 Patient Assessment Form</b>	<b>Pre-visit questionnaires</b>
	<b>1.2 Nursing Patient Assessment Form</b>	<b>Inpatient admission assessment</b>



# Types of CDSS [1]

Types	Sub-types	Examples
<b>1. Documentation Tool</b>		
	<b>1.3 Clinical Encounter Patient Form</b>	<b>Intelligent Referral Form</b>
	<b>1.4 Departmental/ multidisciplinary clinical documentation forms</b>	<b>Emergency department documentation</b>
	<b>1.5 Data Flowsheets</b>	<b>Immunization flowsheet</b>



# Types of CDSS [1]

## 2) Relevant Data Presentation

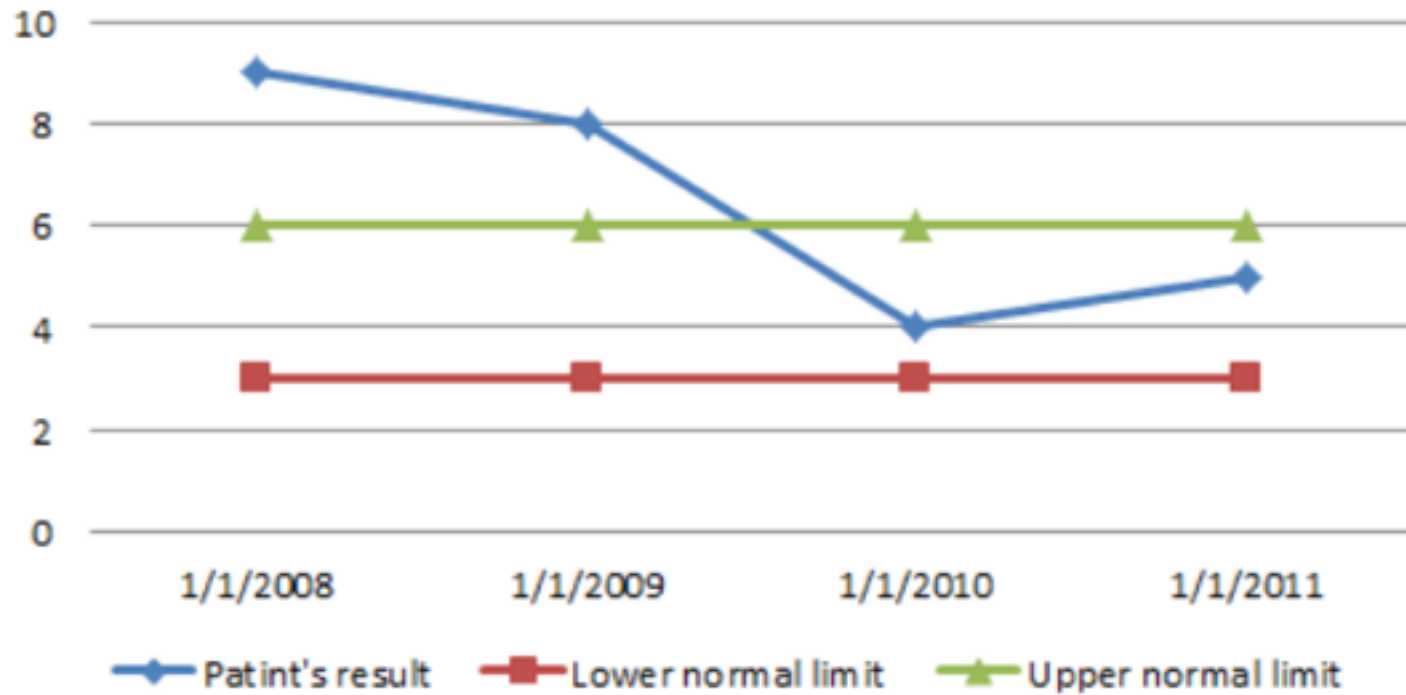
- \*Display relevant data -including costs
- \*Pertinent Data are displayed
- \*Complex Data - to show overall picture
- \*To highlight needed ACTIONS



Untitled Frame



## Trend of FBS



Help

Print

OK

# Types of CDSS [1]

Types	Sub-types	Examples
<b><i>2. Relevant Data Presentation</i></b>		
	<b><i>2.1 Relevant data for ordering</i></b>	<b><i>Display of relevant lab tests when ordering a medication</i></b>
	<b><i>2.2 Choice list</i></b>	<b><i>Suggest dose choice lists</i></b>



# Types of CDSS [1]

Types	Sub-types	Examples
<b>2. Relevant Data</b>		
	2.3 Practice status display	ED tracking display
	2.4 Retrospective/ aggregate reporting/ filtering	Physician “report cards”
	2.5 Environment parameter report	Recent antibiotic sensitivities





# Types of CDSS [1]

## 3) Order Creation Facilitators

- \* Adherence to Standards (Guidelines)
- \* Making the right things EASIEST TO DO

## 4) Protocol and Pathway Support

- \* Provide support for multi-step care plan , protocol and pathway



# Types of CDSS [1]

Types	Sub-types	Examples
<b>3. Order Creation Facilitator</b>		
	<b>3.1 Single-order completers-consequent orders</b>	<b>Prompt Order Consequent Order Suggestions</b>
	<b>3.2 Order sets</b>	<b>General Order Set Post Op Order Set</b>
	<b>3.3 Tools for complex ordering</b>	<b>Guided Dose Active Guidelines</b>



# Types of CDSS [1]

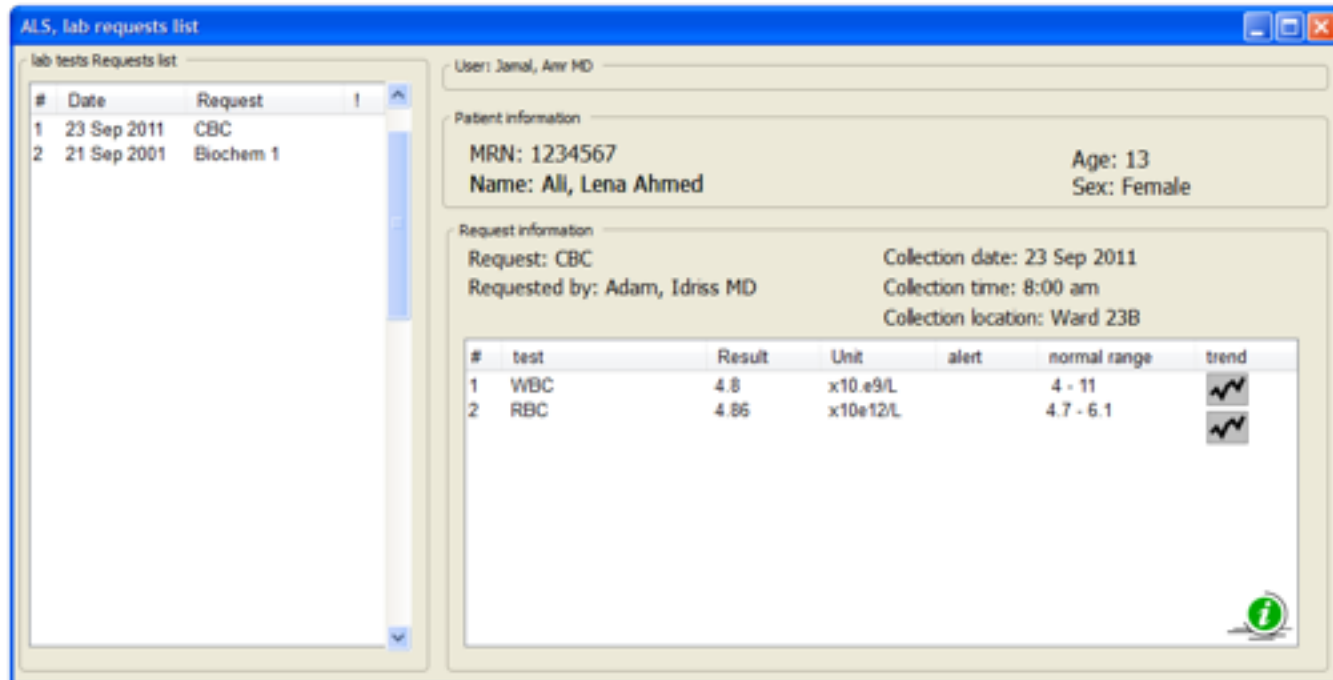
Types	Sub-types	Examples
<b><i>4. Time-based checking &amp; protocol/ pathway</i></b>		
	<b><i>4.1 Stepwise processing of multi-step protocol</i></b>	<b><i>Tools for Monitoring and supporting patient clinical pathway</i></b>
	<b><i>4.2 Support for managing clinical problems</i></b>	<b><i>Computer assistant management algo</i></b>



# Types of CDSS [2]

## 5) Reference Information & Guidance

- Address recognized needs from physicians & patients
- “Infobuttons” - linked to references/standards





The screenshot displays a software window titled "ALS, lab requests list". It features a table of lab requests on the left and a detailed view of a selected request on the right. The table lists two requests: a CBC on 23 Sep 2011 and a Biochem 1 on 21 Sep 2001. The detailed view shows patient information (MRN: 1234567, Name: Ali, Lena Ahmed, Age: 13, Sex: Female) and request information (Request: CBC, Requested by: Adam, Idriss MD, Collection date: 23 Sep 2011, Collection time: 8:00 am, Collection location: Ward 23B). A results table at the bottom shows WBC and RBC values with normal ranges and trend indicators.

#	Date	Request
1	23 Sep 2011	CBC
2	21 Sep 2001	Biochem 1

User: Jamal, Amr MD

Patent information  
MRN: 1234567  
Name: Ali, Lena Ahmed  
Age: 13  
Sex: Female

Request information  
Request: CBC  
Requested by: Adam, Idriss MD  
Collection date: 23 Sep 2011  
Collection time: 8:00 am  
Collection location: Ward 23B

#	test	Result	Unit	alert	normal range	trend
1	WBC	4.8	x10.e9/L		4 - 11	
2	RBC	4.86	x10e12/L		4.7 - 6.1	



# Types of CDSS [2]

## 6) Reactive Alerts and Reminders

- \*Data entry level
- \*Immediate notification for errors and hazards
- \*Lack of an order- reminder
- \*Contradictions to a procedure



# Types of CDSS [1]

Types	Sub-types	Examples
<b><i>5. Reference Information and guidance</i></b>		
	<b><i>5.1 Context-insensitive</i></b>	<b><i>General Link from EMR to a reference program</i></b>
	<b><i>5.2 Context-sensitive</i></b>	<b><i>Direct link to a specific reference program</i></b>



# Types of CDSS [1]

Types	Sub-types	Examples
<b><i>6. Reactive Alerts &amp; Reminders</i></b>		
	<b><i>Alerts to prevent potential errors</i></b>	<b><i>Drug Allergy Alerts Drug Interaction aler Under/Overdose Alert</i></b>



# Summary

## \* CDS

*Provide clinicians or patients with computer-generated clinical knowledge and patient-related information, intelligently filtered or presented at appropriate times, to enhance patient care” [1]*





# References

[1] Carter, J.H. (2008) . Electronic Health Records, 2<sup>nd</sup> edition, American College of Medicine.

[2] Shortliffe, E.H., Cimino, J.J. (2006). *Biomedical informatics: computer applications in health care and biomedicine*, 3<sup>rd</sup> Edition, Springer.



# References

[3] Jaspers , M.N.W, Smeulers, M., Vermuelen, H., Peute, L.W. (2010). Effects of clinical decision-support systems on practitioner performance and patient outcomes: a synthesis of high-quality systematic review findings. *Journal of American Medical Informatics Association*, No 18, pp. 327-334.

[4] Moxey, A., Robertson, J., Newby, D., Hains, I. , Williamson, M., Pearson, S.A. (2008). Computerized clinical decision support for prescribing: provision does not guarantee uptake. *Journal of American Medical Informatics Association*, No 17, pp. 25-33.

