

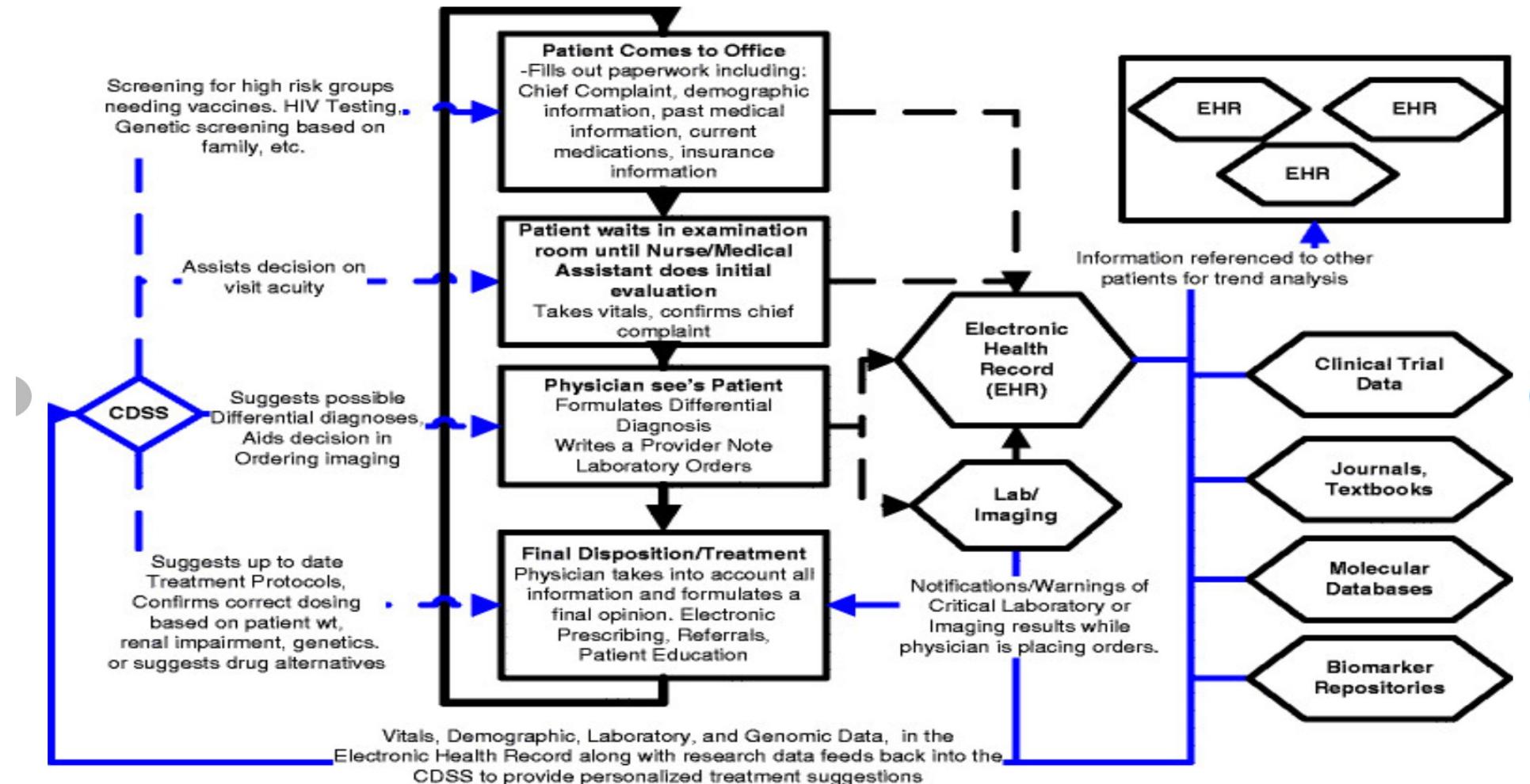
Clinical Decision Support System (CDSS)

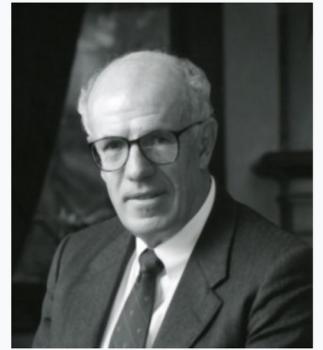
What is Clinical Decision Support (CDS)?

Clinical decision support is a process for enhancing health-related decisions and actions with pertinent, organized, clinical knowledge, and patient information to improve health and healthcare delivery. Information recipients can include patients, clinicians, and others involved in patient care delivery; information delivered can include general clinical knowledge and guidance, intelligently processed patient data, or a mixture of both; and information delivery formats can be drawn from a rich palette of options that includes data and order entry facilitators, filtered data displays, reference information, alerts, and others.

Osheroff JA, Levick DL, Saldana L, Velasco FT, Sittig DF, Rogers KM, et al. Improving Outcomes with Clinical Decision Support: An Implementer's Guide, 2nd ed., Healthcare Information and Management Systems Society, Chicago, IL; 2012

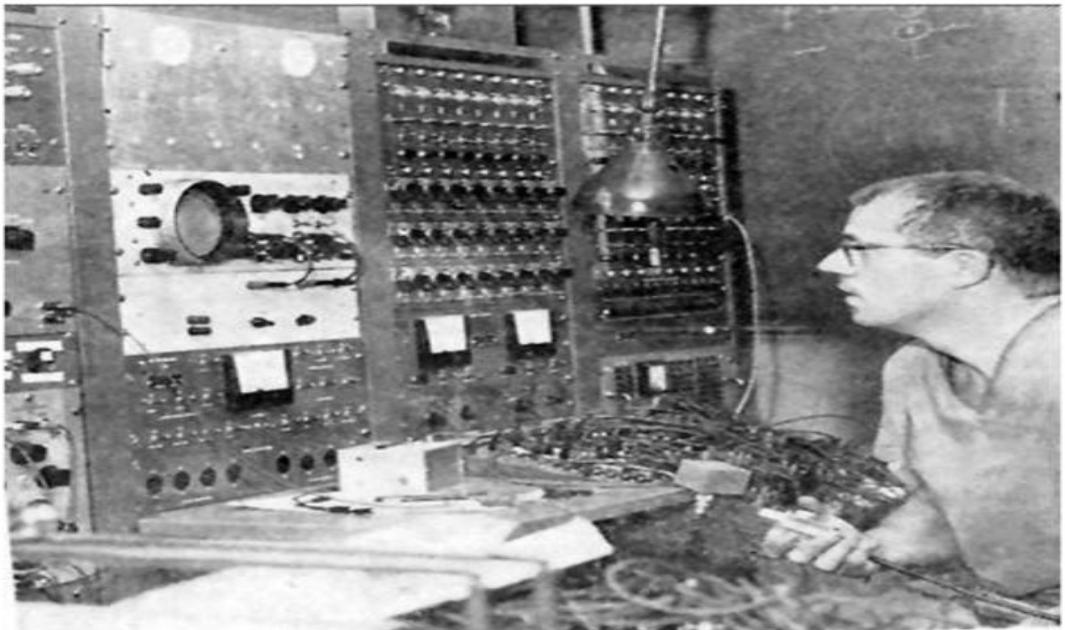
Workflow of a patient visit





Pioneer of CDS

- Dr. Warner was a cardiologist from University of Utah and the first doctor to use computer to facilitate clinical decision making.
- He developed a mathematical model to diagnose heart disease.



Dr. Warner with his first computer.

Homer R. Warner award

It includes a \$1000 prize, and is presented each year at the American Medical Informatics Association (AMIA). It is named for Warner. It is awarded for the paper that best describes approaches to improving computerized information acquisition, knowledge data acquisition and management, and experimental results documenting the value of these approaches.

CDSS

- CDSS is an application that analyzes data to help healthcare providers make decisions and improve patient care.
- A CDSS focuses on using knowledge management to get clinical advice based on multiple factors of patient-related data.
- It enables integrated workflows, provides assistance at the time of care and offer care plan recommendations.
- The purpose of CDSS is to assist healthcare providers, enabling an analysis of patient data and using that information to aid in formulating a diagnosis.
- It offers information and insights to clinicians and primary care providers to improve the quality of care
- It can lower costs and increase efficiency

CDSS usage

- CDSS can apply machine learning and deep learning methods to examine a patient's medical history in conjunction with relevant clinical research.
- The results can be used to predict future events, such as drug interactions, or flag disease symptoms.
- It offers reminders for preventive care, gives alerts about potential dangerous drug interactions, alerts clinicians to possible redundant testing
- It can be used to flag patients who were improperly diagnosed or either missed or given the wrong dosage of medication

HITECH Act

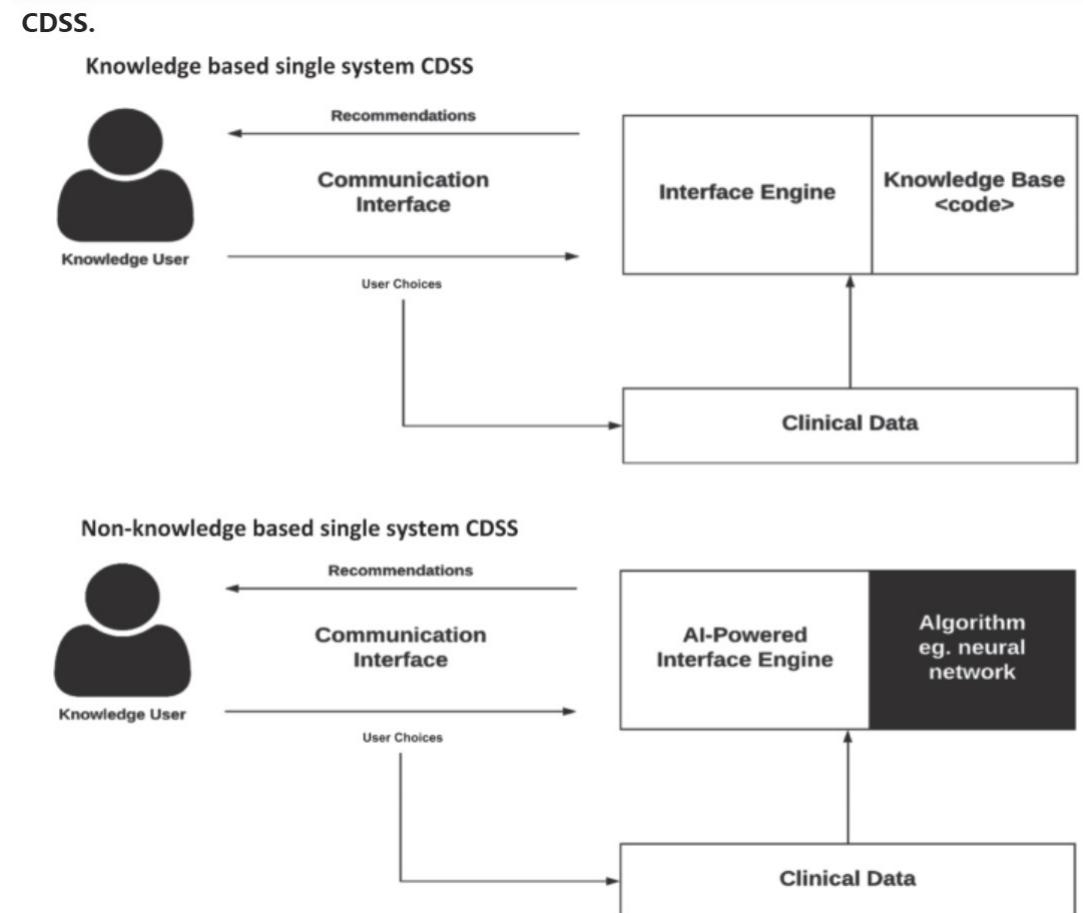
- Health Information Technology for Economic and Clinical Health Act (HITECH Act) stipulates that providers had to demonstrate the meaningful use of health IT by 2015 or face a reduction in Medicare reimbursements the following year.
- Under meaningful use, providers must implement one clinical decision support rule, including diagnostic test ordering and the ability to track compliance with that rule.

Meaningful Use: 13 Core Objectives

1. Computerized provider order entry (CPOE)
2. Drug-drug and drug-allergy checks
3. Maintain an up-to-date problem list of current and active diagnoses
4. E-Prescribing (eRx)
5. Maintain active medication list
6. Maintain active medication allergy list
7. Record demographics
8. Record and chart changes in vital signs
9. Record smoking status for patients 13 years or older
10. Implement clinical decision support
11. Provide patients with the ability to view, download, or transmit their health information online
12. Provide clinical summaries for patients for each office visit
13. Protect electronic health information

CDSS: Knowledge-based or not

- There are two main types of CDSS
 - Knowledge based (expert system): applies rules to patient data using an inference engine and displays the results. Most of the rules are if-then rules.
Example:
 - If drug A is taken and drug B is prescribed, then an alert should be issued.
 - Non-Knowledge based system:
 - ML/DL/AI
 - Data and algorithm driven



Knowledge based systems

- Functions
 - Alerts and reminders
 - Diagnostic assistance
 - Therapy critiquing and planning
 - Prescribing decision support systems
 - Information retrieval
 - Image recognition and interpretation
- Contain clinical knowledge, specially defined task, and are able to give reasons with data from individual patients
- Form a set of rules

CDSS components

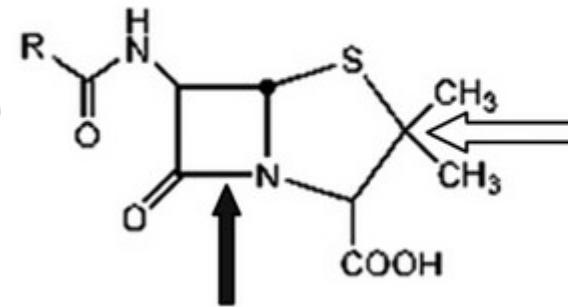
- Encompassing a variety of tools to enhance decision-making in the clinical workflow. These tools include:
 - computerized alerts and reminders to care providers and patients
 - clinical guidelines
 - condition-specific order sets
 - focused patient data reports and summaries
 - documentation templates
 - diagnostic support
 - contextually relevant reference information among other tools.



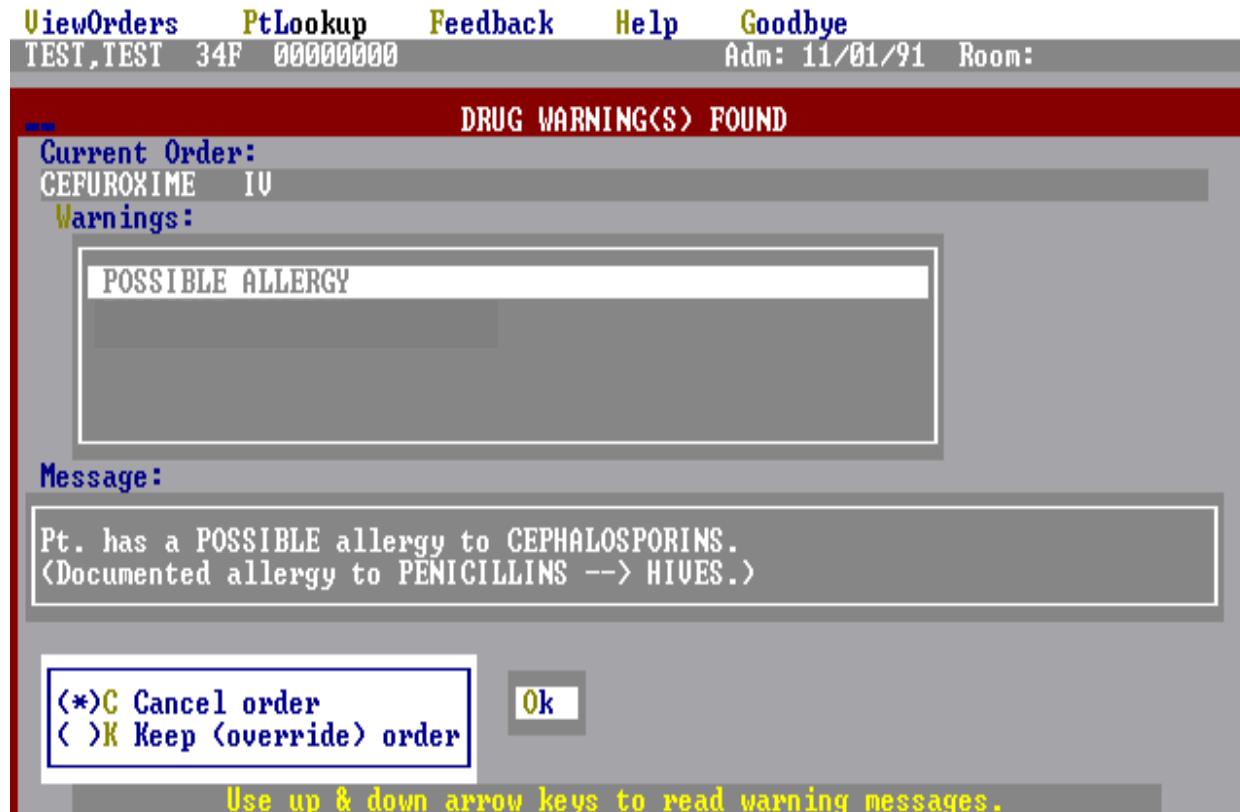
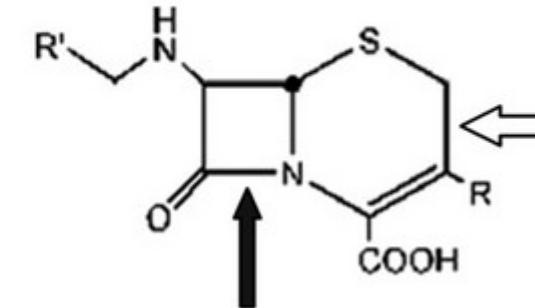
Alerts and reminders

- Real-time situations
- Can warn changes in patient's condition
- Might scan laboratory test results, drug or test order, or the EMR
- Send reminder or warnings, either immediate on screen feedback or via email
- Reminds to notify clinicians of important tasks to follow.

✖ Penicillin



Cephalosporin



Low potassium

Also called: Hypokalemia

OVERVIEW

TREATMENTS

Response to abnormal lab results

A blood level that is below normal in potassium, an important body chemical. The problem can result in fatigue, muscle cramps, and abnormal heart rhythms.

[View PtLookup](#)

Patient: H_____, E_____ 65F 06215446 Adm: 08/17/94 Room: 12B-351
Time: 10/19/94 05:39 AM Alert#38269 12B phone: x7865
Alert: DANGEROUSLY LOW SERUM POTASSIUM
Reason: <BLOOD> K = 3.2 at 04:22 AM, 10/19/94
Patient is currently on DIGOXIN.

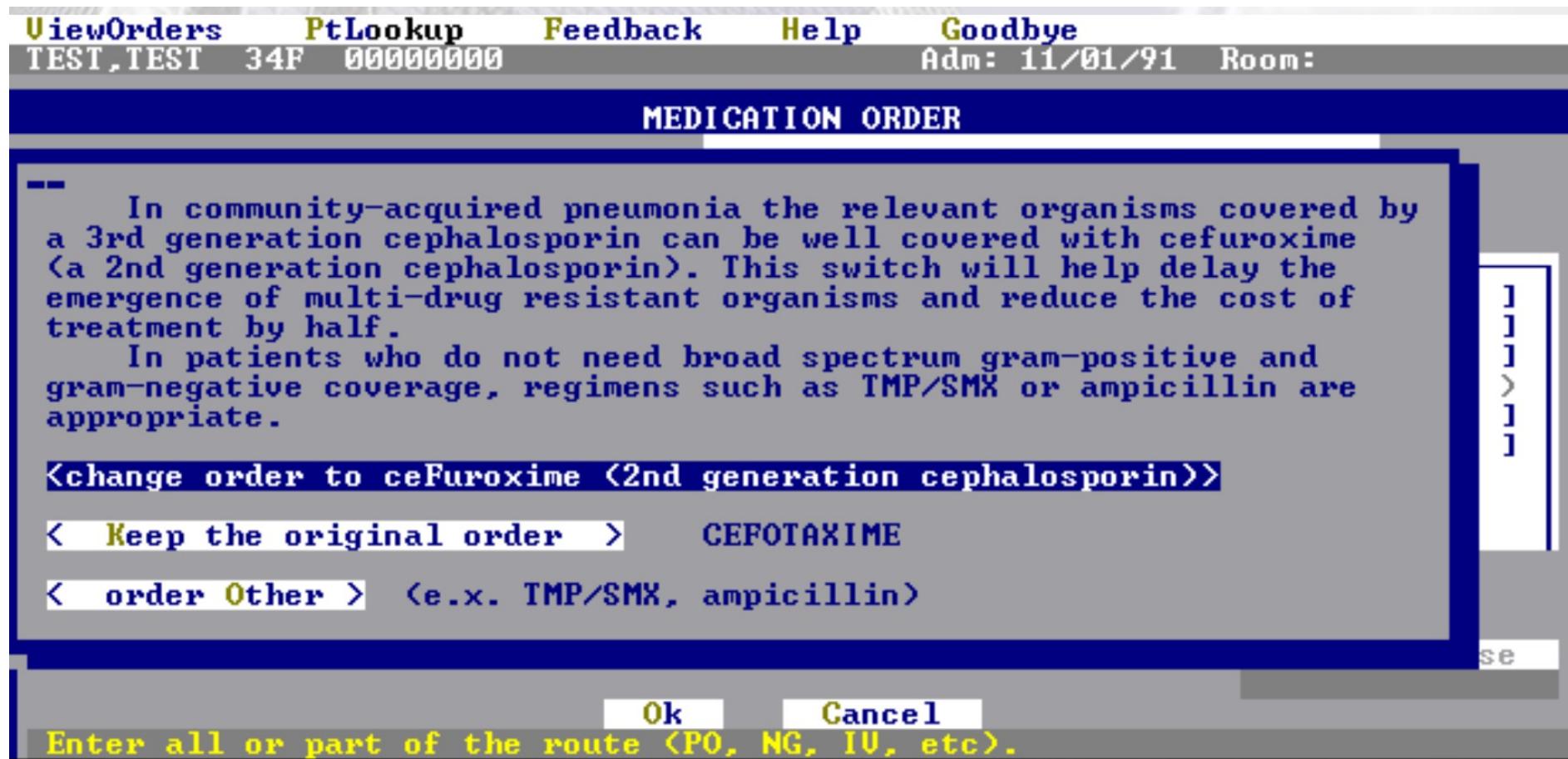
Relevant medications: [Alert Details](#)
LASIX 20 MG IV BID Starting on 10/18 (10/17)
DIGOXIN EVEN days:.125; ODD days:.25 PO (09/28)

Actions:

- A D/C or EDIT relevant medications
- B Order POTASSIUM CHLORIDE IV
- C Order POTASSIUM CHLORIDE PO
- D Order set: STAT EKG
- E Order set: STAT K

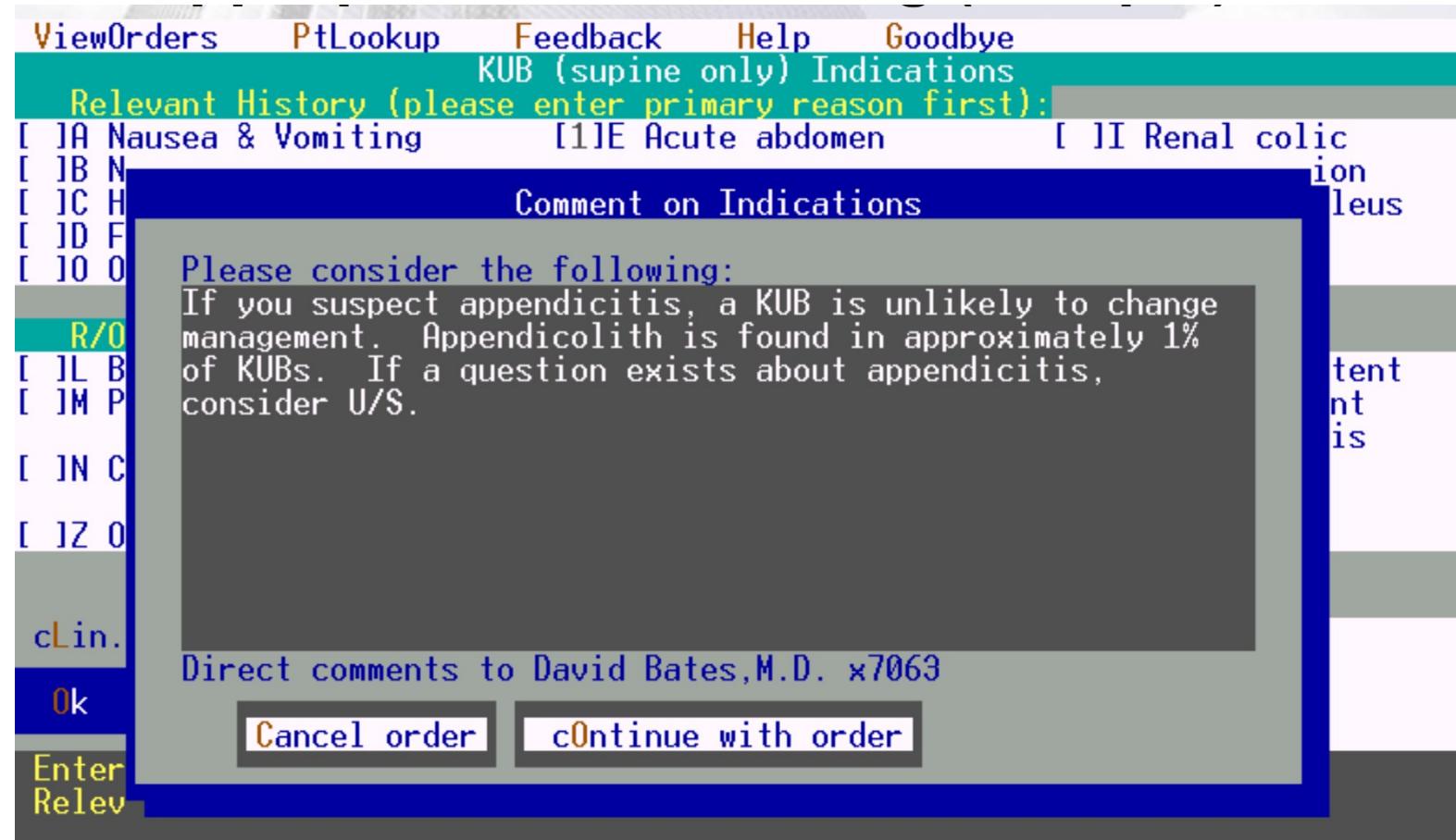
Ganesan, Shridar, M.D., Ph.D. Bp#2710 was paged on 05:40 AM Oct 19, 1994
Covering M.D.: Morrow, David Andrew, M.D. Bp#5336 pAge M.D.
dOne <done, Go to OE> comments Logic

Drug prescription critique



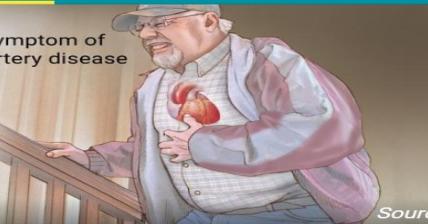
Appropriate test order

The kidneys-ureters-bladder (KUB) radiographic view is typically used to visualize an appendicolith in a patient with symptoms consistent with **appendicitis**. This finding is highly suggestive of **appendicitis**, but appendicoliths also occur in fewer than 10% of cases.



U/S is ultrasound

Can be a symptom of coronary artery disease



A type of chest pain caused by reduced blood flow to the heart.

Patient has been diagnosed with Angina.

One click of a button looks up the evidence-based treatment and patient management information relevant to this patient. No searching or log-in needed!

Diagnosis/Problem Related Documents

- Angina (Disorder)
- Acute Chest Pain (DDx, Adolescent)
- Angina (Patient Handout)

Summary of therapies

- Medical management is the mainstay of treatment, often controlling angina satisfactorily for many years
- Catheter interventions and coronary bypass surgery are treatments, not cures, and underlying issues of risk factor management must still be addressed
- The use of nitroglycerine prior to physical activity can often prevent angina and should be recommended to active patients with predictable angina

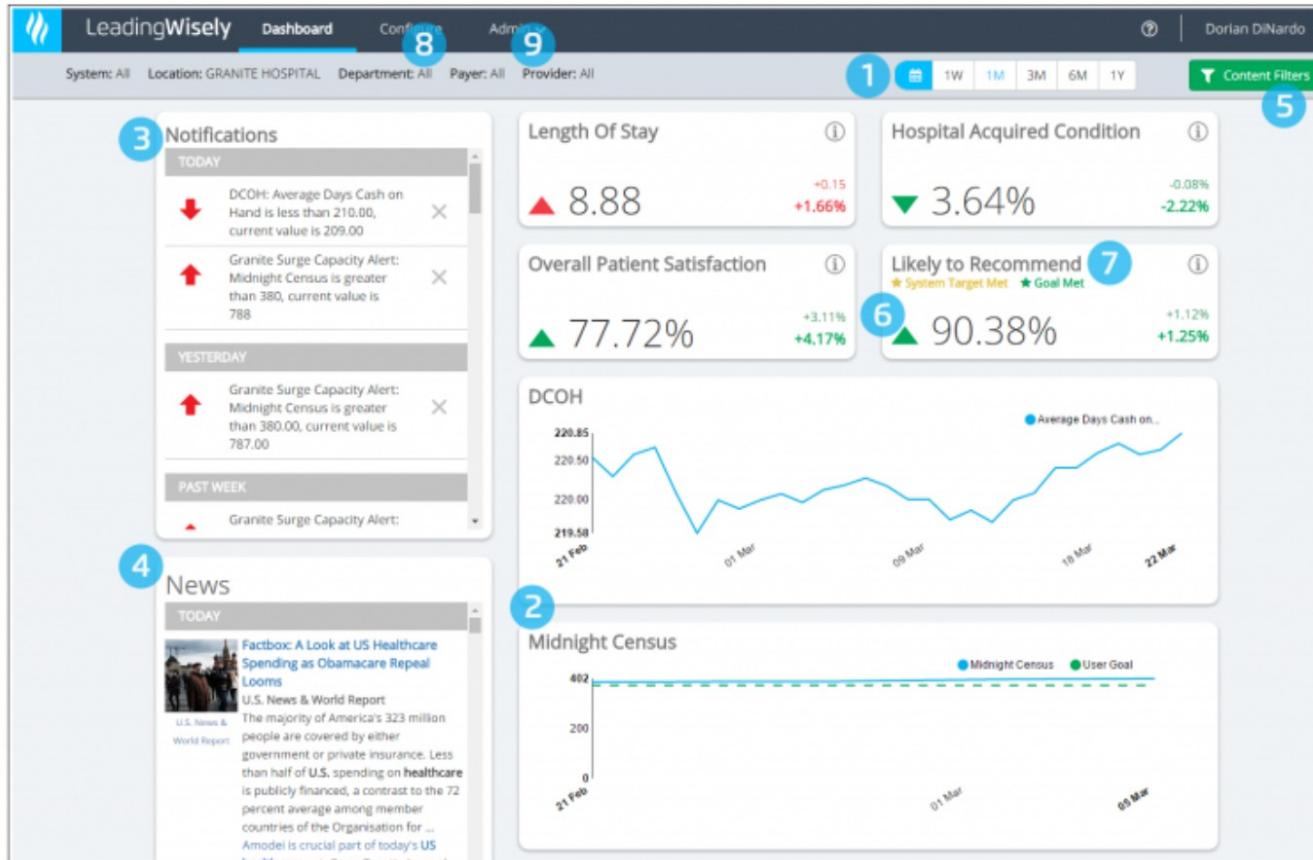
In treatment of patients with angina, the following four strategies should be kept in mind.

Pharmacological management:

Dashboard

Leading Wisely

- 1 Watchlists that show changes based on the selected calendar.
- 2 User-configurable charts: bar, line, goal, control, and more.
- 3 Notifications set up by user.
- 4 News feed set up by organization.
- 5 Content filters allowing for drill-down into the measures.
- 6 System Target assigned by measure.
- 7 Goal set by the user.
- 8 Configure: user self-serves measures and other content for their dashboard.
- 9 Admin: customizable functions for the application.

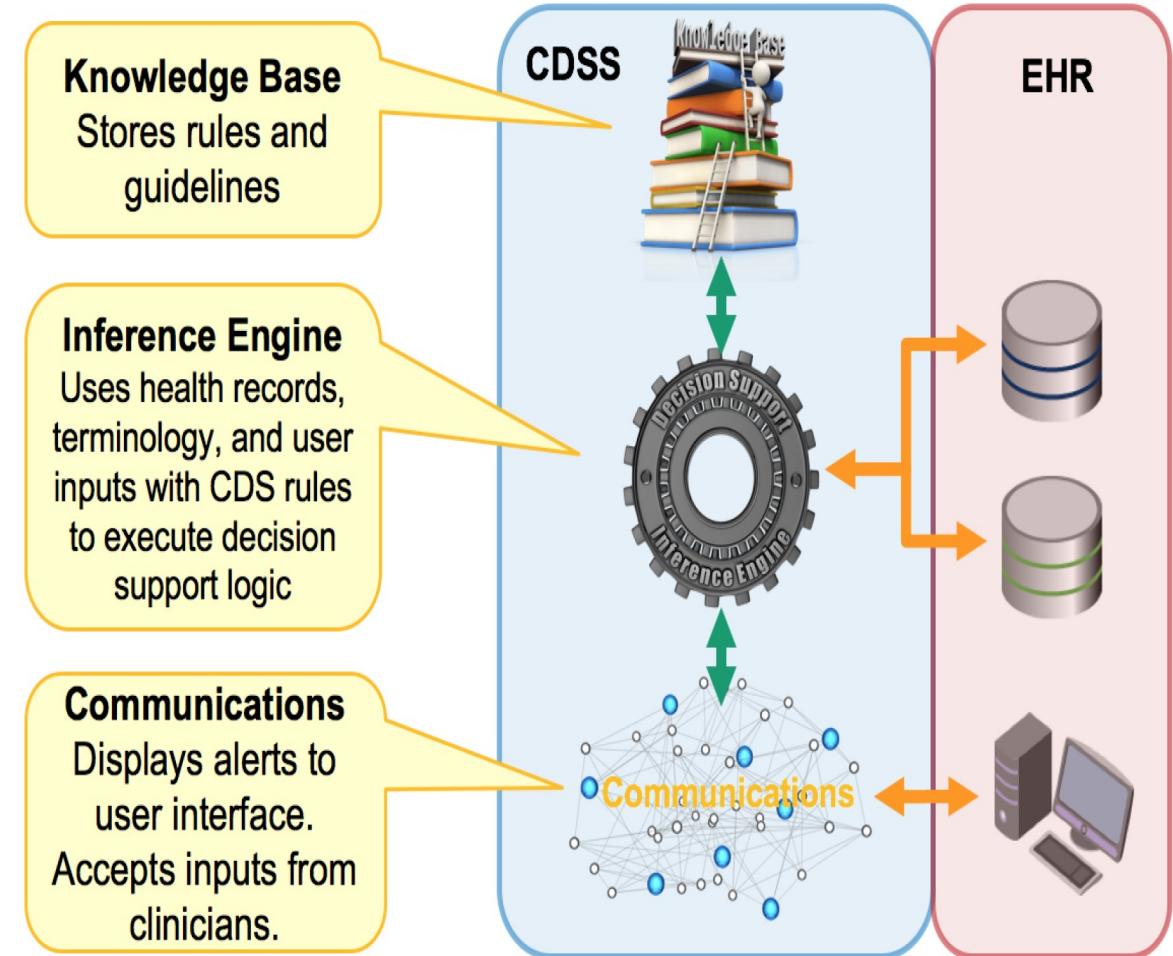
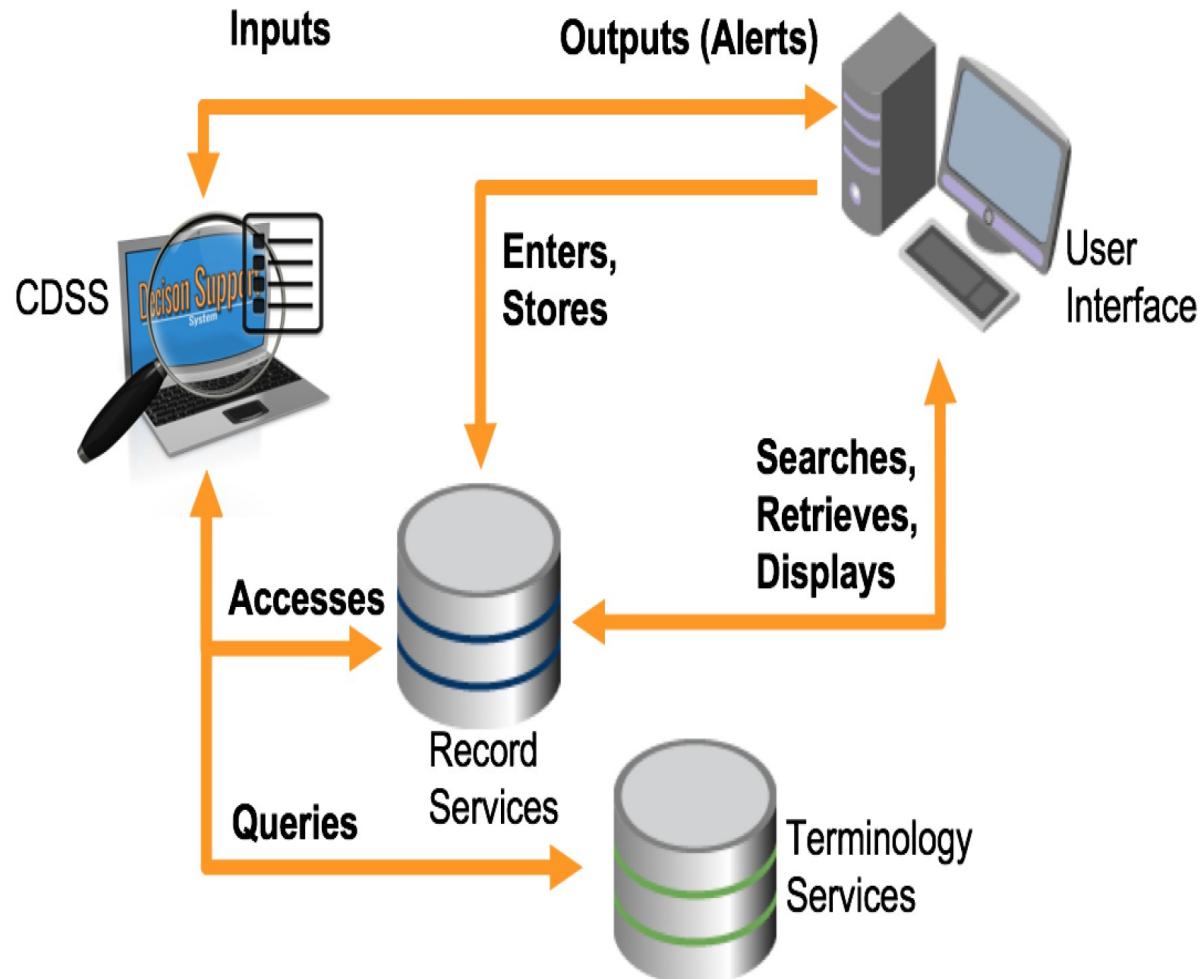


Examples of The Value of CDSS

- Quality
 - By guiding users to best practices
- Safety
 - By verifying an action was the intended one
- Cost
 - Catching duplicate or unnecessary orders
- Documentation
 - By bringing forth documentation tools based on a diagnosis or problem
- Communication
 - Of system priorities or initiatives
 - Among providers of patient status

Mechanism of CDSS: SNOMED CT Concept Model

- Concept
 - Identified by a unique SNOMED CT Concept Identifier
 - 195967001- Asthma
 - Human-readable descriptions for each concept
- Relationships
 - is-a relationship (relates a concept to a parent or supertype) define the hierarchy of concepts
 - Bacterial pneumonia and Viral pneumonia both have an is-a relationship to Infective pneumonia
 - Additional attributes
 - Viral pneumonia has a Causative agent relationship to the concept Virus.
- Description Logic
 - DL reasoned: reasoning
 - Testing expressions for subsumption and equivalence.
 - If a rule will be triggered by Asthma, it will be triggered if it is Acute asthma.



Rules

Event

A CDS event is the clinical situation in which a decision support rule will be applied. First something must happen before the rule can be utilized. Examples of CDS events include:

- A clinician is prescribing a drug to a patient
- A nursing supervisor is reviewing a list of patients previously diagnosed with cancer
- A clinician is assessing a patient enrolled in a jurisdictional diabetes monitoring program

Condition

A CDS condition defines the question(s) that must be answered to determine the outcome of the rule. Examples of conditions include:

- Does the usual drug of choice for this patient's condition contain a substance to which the patient is allergic?
- Have any patients with a suspected cancer diagnosis NOT been referred to a specialist within 14 days of diagnosis?
- Has the patient with a previous diagnosis of diabetes type II NOT had HBA1C tested within the last 12 months?

Action

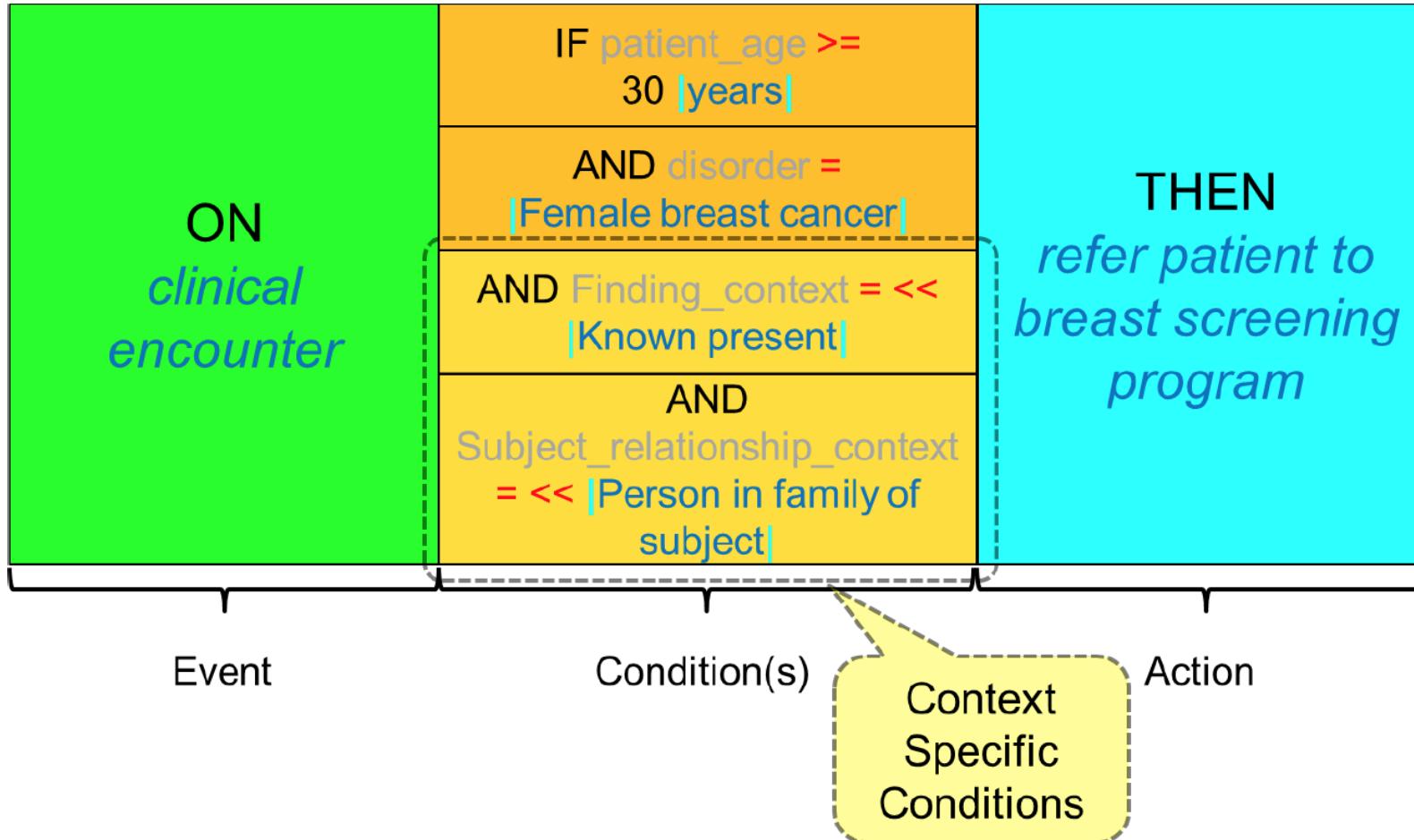
The CDS action describes what should be done if the condition evaluates to true. Examples of actions include:

- Alert the clinician and suggest a safe alternative medication
- Refer patients to an oncology specialist
- Order HBA1C test

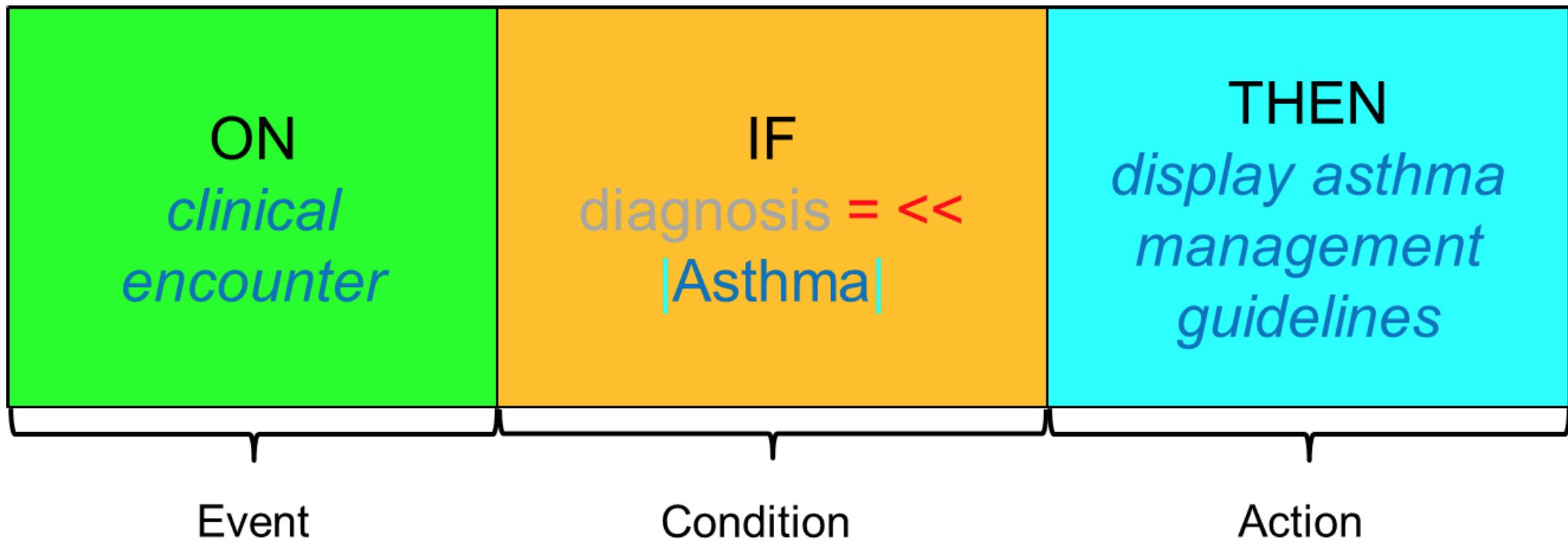
Context in Rules

Technique for Representing Context	Example				
Precoordinated as a single SNOMED CT concept identifier explicitly representing family history of diabetes mellitus.	160303001 Family history: Diabetes mellitus				
Postcoordinated as a SNOMED CT expression that includes a concept representing a family history of disorder and specifies the diabetes mellitus as the disorder.	281666001 Family history of disorder : 246090004 Associated finding = 73211009 Diabetes mellitus				
A context specific family history section in the record structure	<table border="1"><tr><td>Family History Record Section</td><td>73211009 Diabetes mellitus </td></tr></table>	Family History Record Section	73211009 Diabetes mellitus		
Family History Record Section	73211009 Diabetes mellitus				
A separate field in the record structure to indicate the context of the disorder recorded	<table border="1"><tr><th>Disorder</th><th>Context</th></tr><tr><td>73211009 Diabetes mellitus </td><td>281666001 Family history of disorder </td></tr></table>	Disorder	Context	73211009 Diabetes mellitus	281666001 Family history of disorder
Disorder	Context				
73211009 Diabetes mellitus	281666001 Family history of disorder				

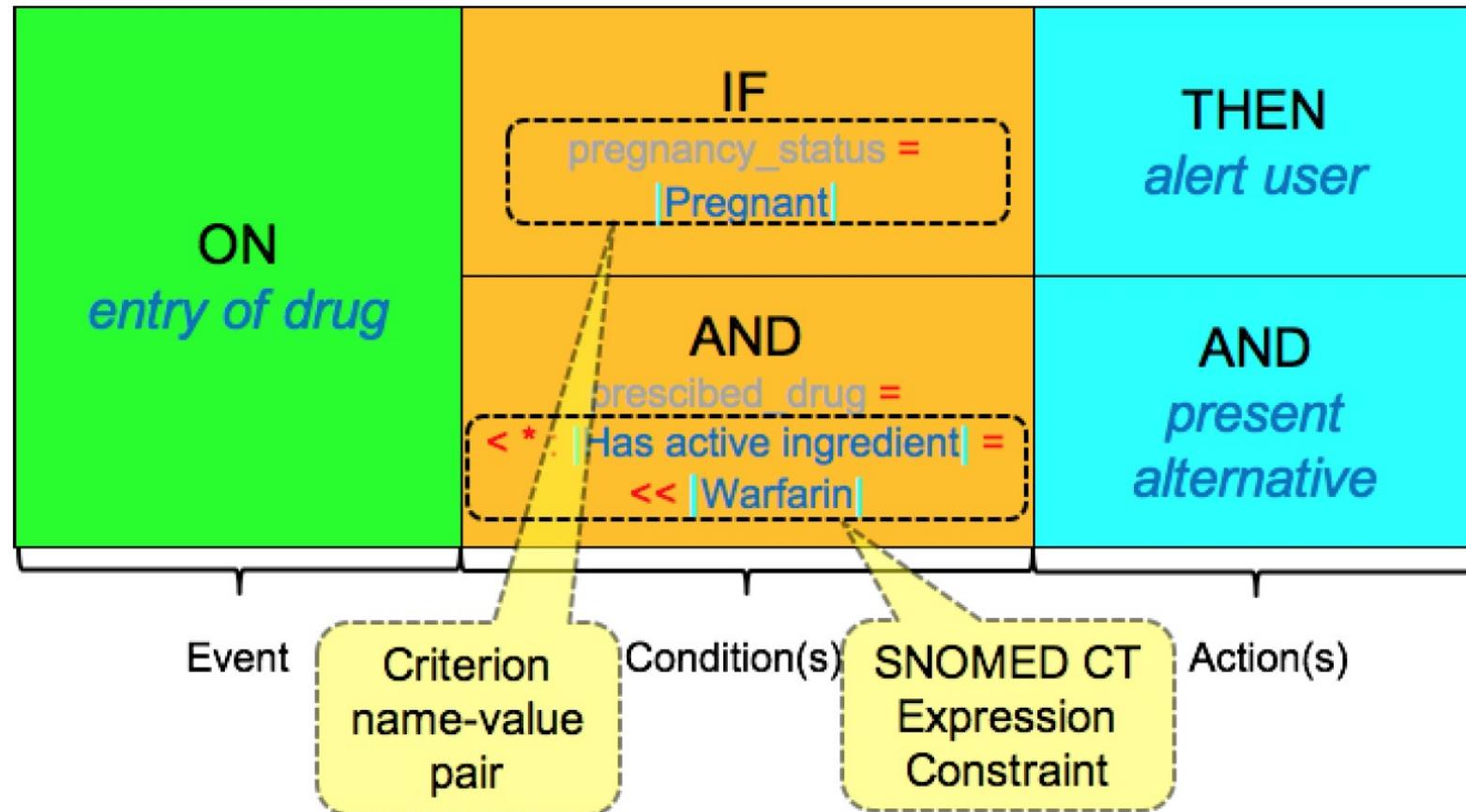
Context in a rule



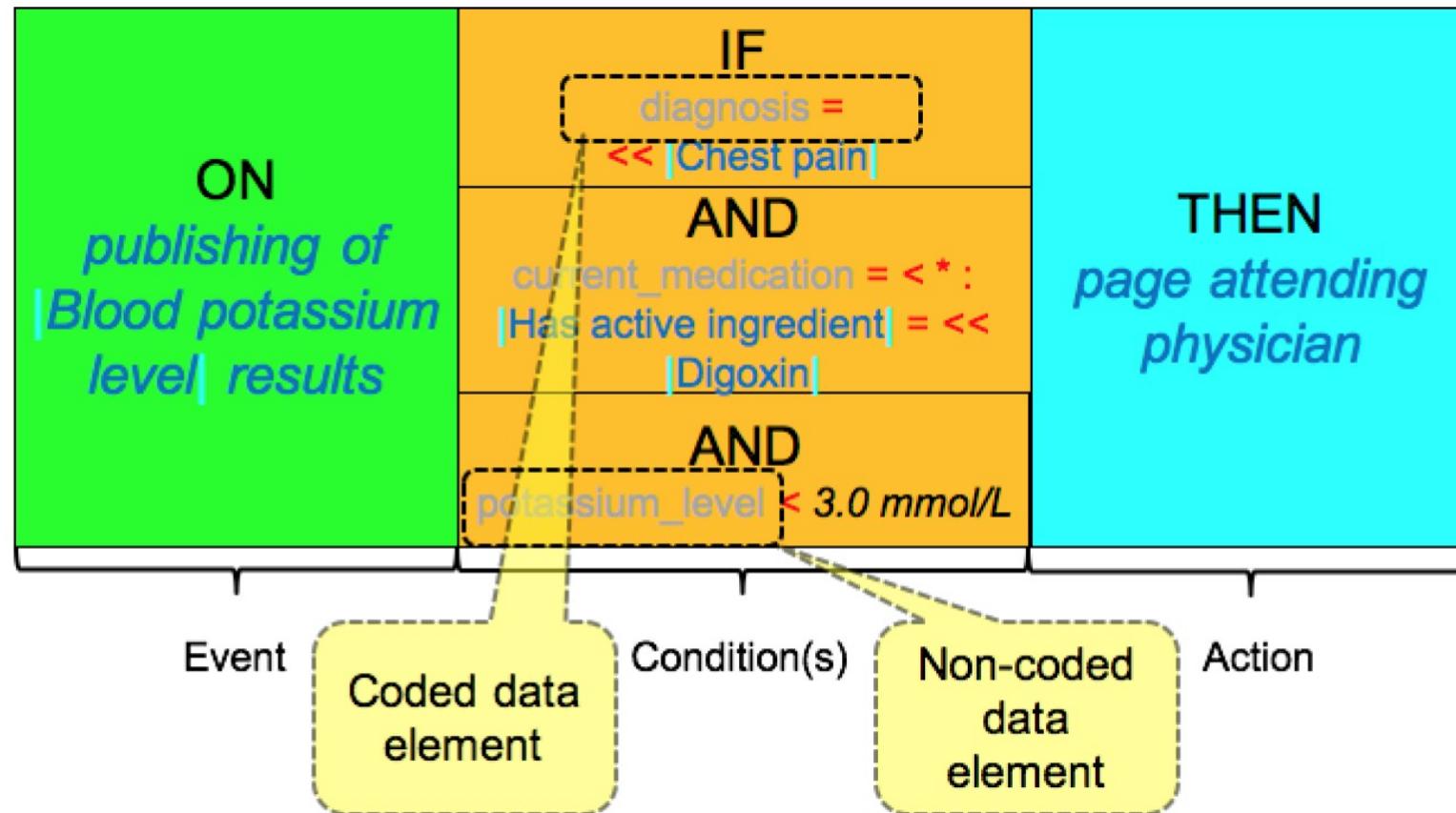
Rules and actions



Rules and actions



Rules and actions



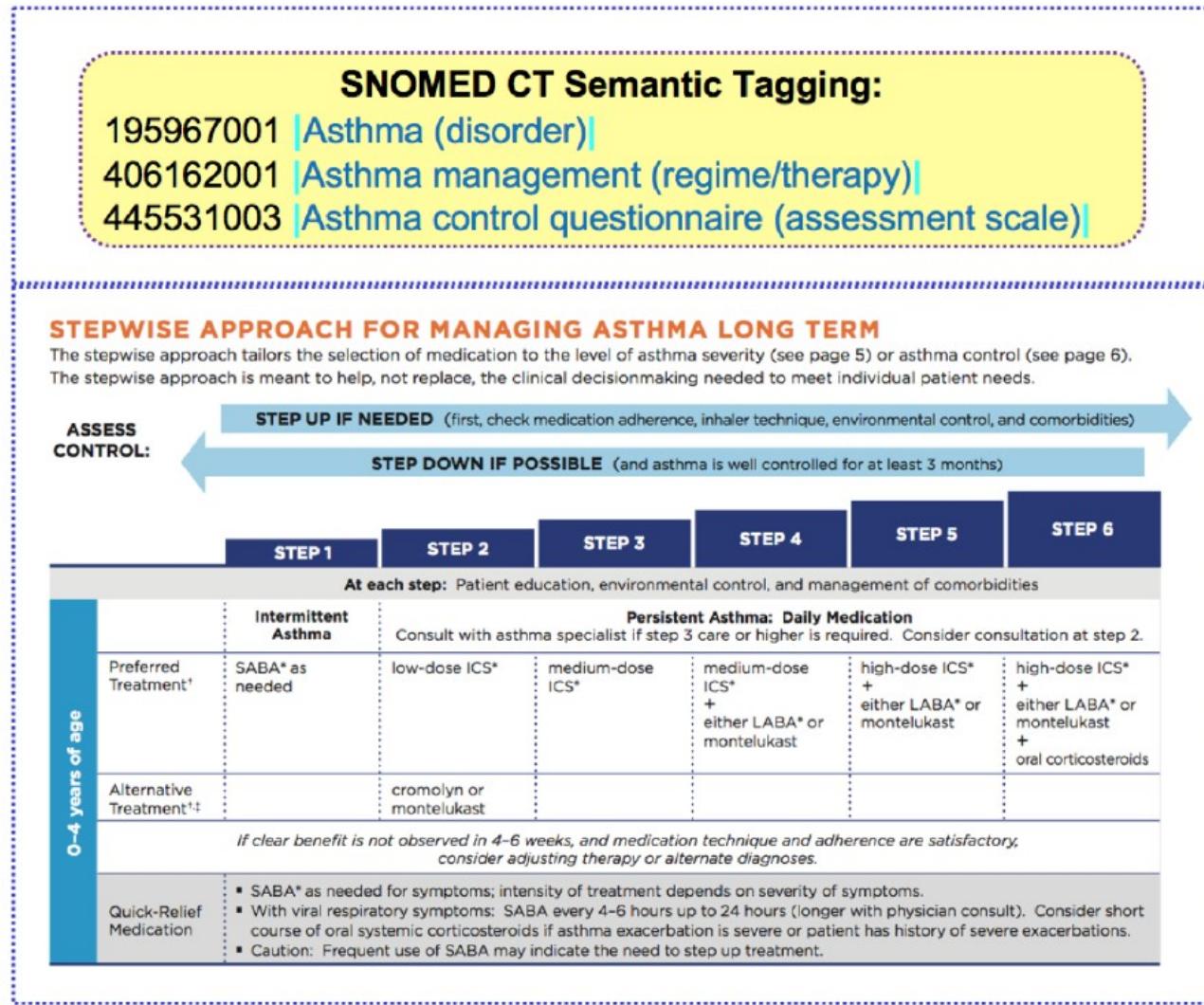
Clinical Guidelines and SNOMED CT

- Clinical guidelines can be linked to SNOMED CT to enable the automated display of contextually relevant knowledge resources.
 - A guideline can be linked to a SNOMED CT concept using semantic tags
 - SNOMED CT concepts can be associated with guidelines using a reference set.
 - Automated display of a contextually relevant guideline based on the selection of a SNOMED CT concept in a data entry protocol.

A **reference set** can be used to represent a subset of components (concepts, descriptions or relationships). A **reference set** may also associate referenced components with additional information such as: ... Mapping between **SNOMED CT** concepts and other systems **codes**, classifications, or knowledge resources.

Jul 16, 2019

Smart Tag



Document header
(contains semantic tags as metadata)

Document body
(contains clinical guideline)

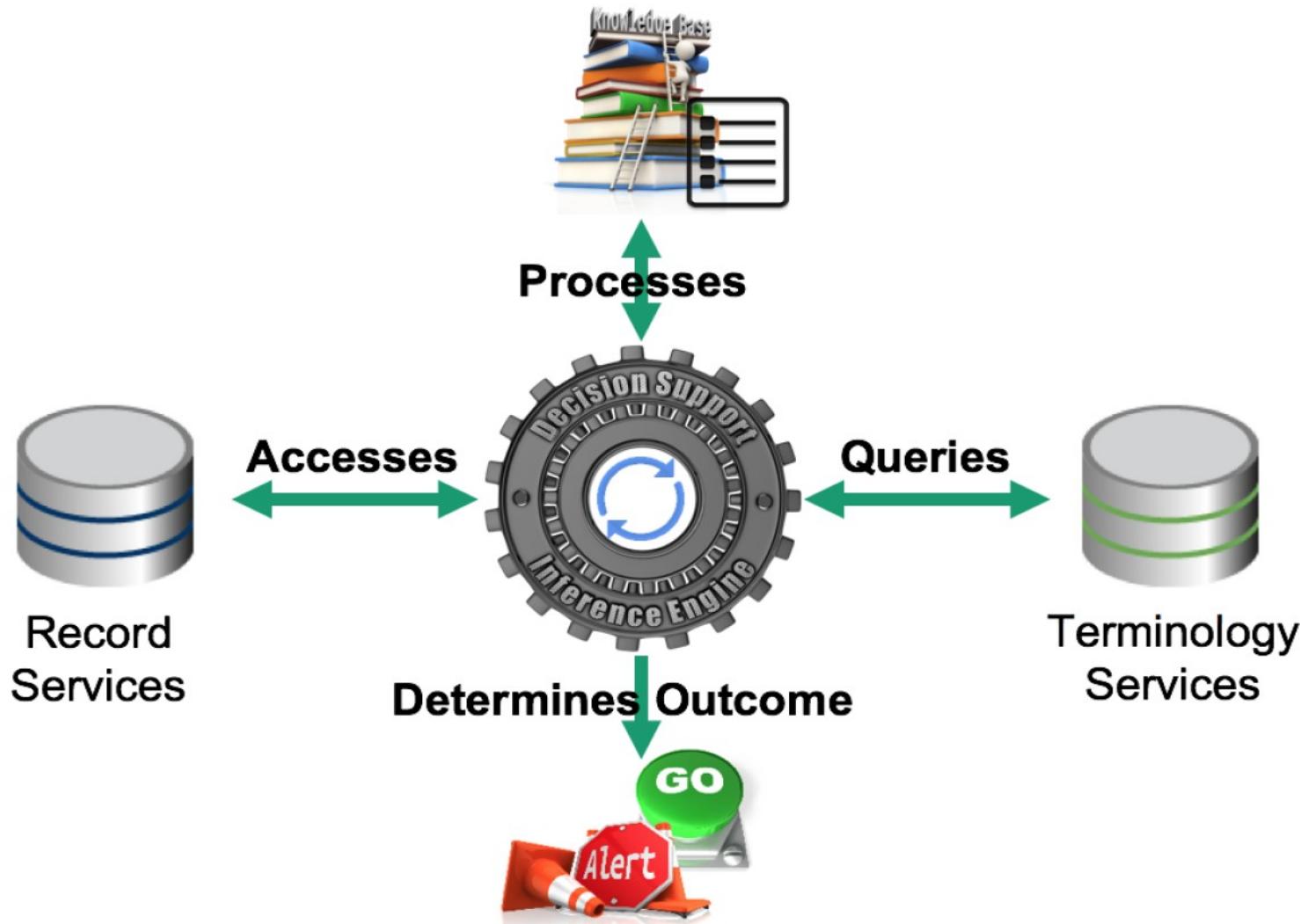
Reference Set

refsetId	referencedComponentId	Annotation
719999999107 Guideline annotation reference set	195967001 Asthma (disorder)	http://www.example.com/asthma_guideline
719999999107 Guideline annotation reference set	406162001 Asthma management (regime/therapy)	http://www.example.com/asthma_guideline
719999999107 Guideline annotation reference set	445531003 Asthma control questionnaire (assessment scale)	http://www.example.com/asthma_guideline

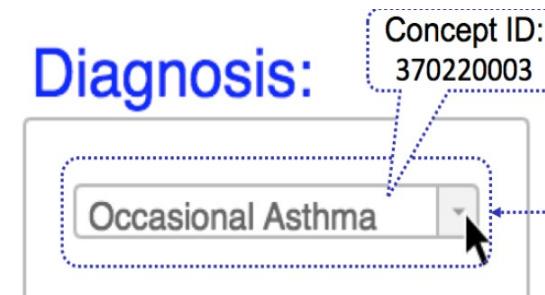
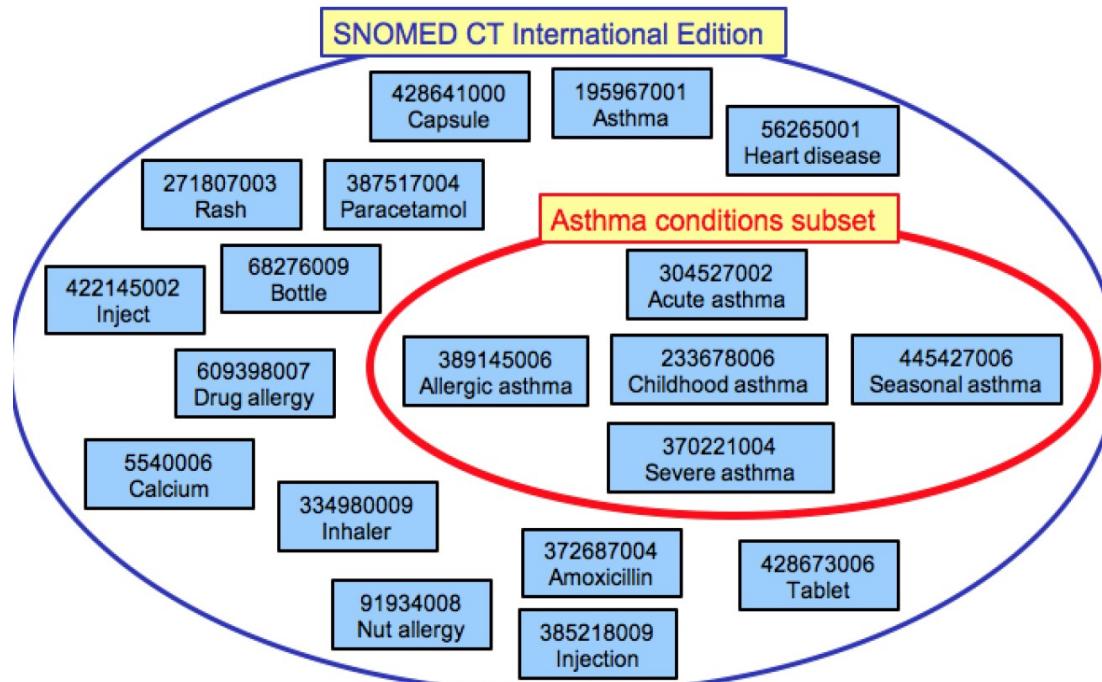
IF diagnosis = << [[+ \$semanticTag]]
THEN display clinical guideline

IF diagnosis = << |Asthma|
THEN display NIH Asthma Care Quick Reference

Inference



Subset



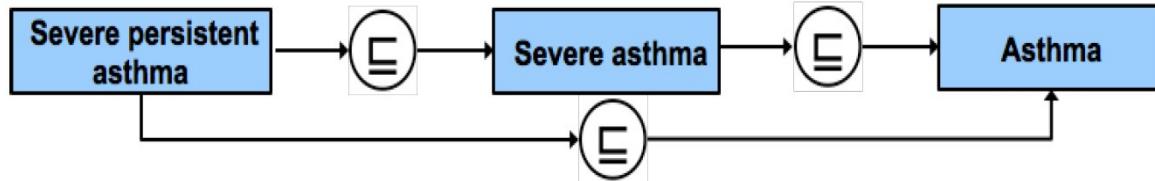
Technique: Checks for membership.
^ 239999999106
|Asthma conditions reference set|

- Match:
 - No
- Condition:
 - False
- Action:
 - Not triggered

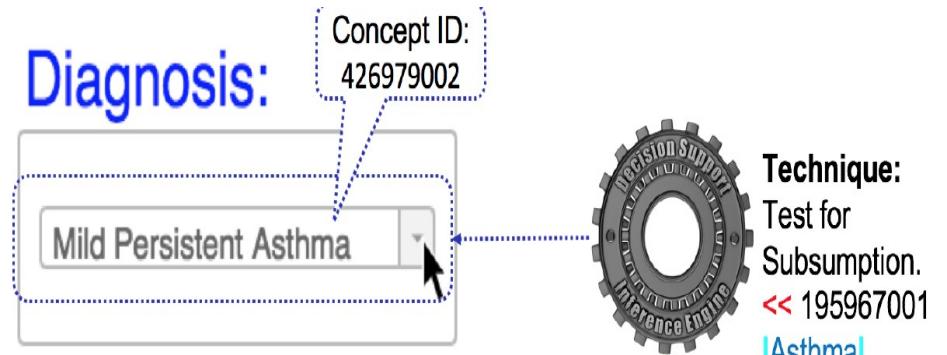
Asthma Conditions Subset:

Id	Term
304527002	Acute asthma
389145006	Allergic asthma
233678006	Childhood asthma
445427006	Seasonal asthma
370221004	Severe asthma

Subsumption



IF diagnosis = << 195967001 Asthma	THEN display asthma management guidelines
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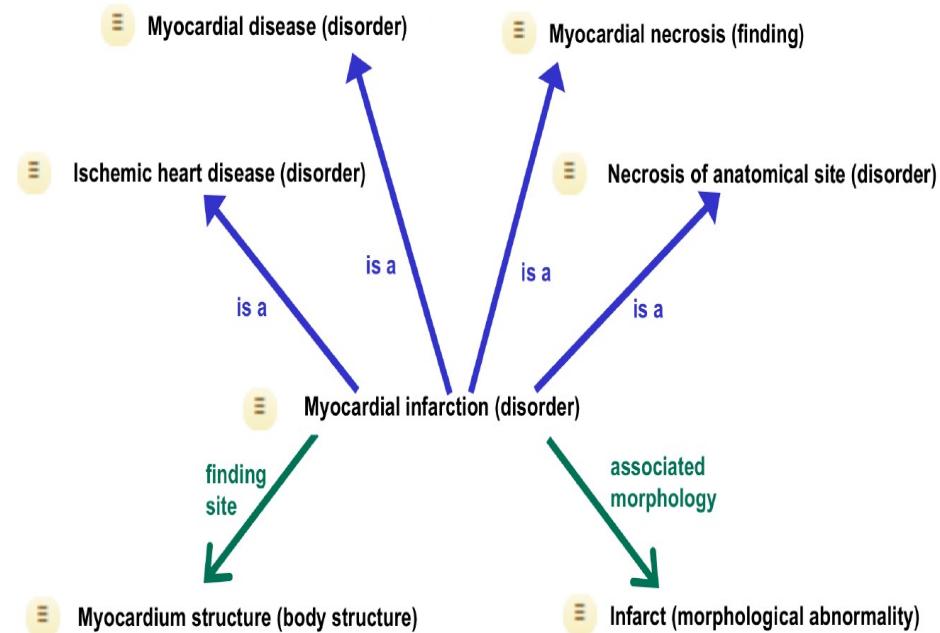


Transitive Closure Table:

Subtype	Supertype
304527002	195967001
389145006	195967001
426979002	195967001
445427006	195967001
370221004	195967001
	195967001

- Match:
 - Yes
- Condition:
 - True
- Action:
 - Triggered

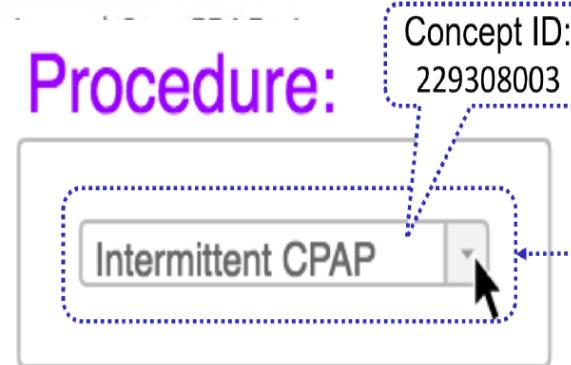
Relationship



IF procedure = << 71388002
 |Procedure| : 363704007 |Procedure site| << 20139000 |Structure of respiratory system|
 THEN
 consult *respirologist*



Procedure:



SNOMED CT Relationships Table:

sourceld	destinationId	typeId
229308003	128258000	363702006
229308003	302803009	363702006
229308003	262202000	363703001
229308003	20139000	363704007
229308003	20139000	405813007
229308003	47545007	116680003
229308003	20139000	363704007

Technique:
 Examine Defining Relationships.
 << 71388002
 |Procedure| : 363704007
 |Procedure site| << 20139000 |Structure of respiratory system|

Communication

The image shows a screenshot of a medical software interface, likely Practice Fusion, displaying a patient chart for 'Sophia Patient' (PRN: PS452226, 45 yrs F). The chart includes sections for 'Summary', 'Timeline', 'Profile', and 'Actions'. A red box highlights a clinical decision support (CDS) notification about Pompe Disease, which states: 'Pompe Disease: This patient has clinical markers that are considered at risk for Pompe Disease. Consider ordering a GAA enzyme activity assay to confirm the absence or presence of the diagnosis.' A blue arrow points from this notification to a yellow callout box containing the text: 'CDS Notifications: Patient has clinical markers that are considered a risk for Pompe Disease. Consider Ordering GAA enzyme activity assay to confirm absence or presence of diagnosis. Reference Information.' Below the chart, a 'Flowsheets' section shows a 'Vitals' table with the following data:

	05/24/16 12:22 PM
Height	64 in
Weight	151 lb
BMI	25.92
BMI Percentile	...

On the right side of the interface, a separate window is open showing a research article from HHS Public Access. The article is titled 'CONSENSUS TREATMENT RECOMMENDATIONS FOR LATE-ONSET POMPE DISEASE' and is authored by Edward J. Cupler, MD, Kenneth J. Berger, MD, Robert T. Leshner, MD, Gil J. Wolfe, MD, Jay J. Han, MD, Richard J. Barohn, MD, John T. Kissel, MD, and the AAEM CONSENSUS COMMITTEE ON LATE-ONSET POMPE DISEASE'. The article is available in PMC3534745 and can be accessed via the URL www.ncbi.nlm.nih.gov/pmc/articles/PMC3534745/.

Reference

- Sutton, R.T., Pincock, D., Baumgart, D.C. *et al.* An overview of clinical decision support systems: benefits, risks, and strategies for success. *npj Digit. Med.* **3**, 17 (2020). <https://doi.org/10.1038/s41746-020-0221-y>