



# Clinical Decision Support:

## What's next

**Jonathan Teich, MD, PhD**

CMIO, Elsevier

Depts. of Medicine and Emergency

Medicine, Harvard

Dept. of Emergency Medicine, Brigham &  
Women's Hospital

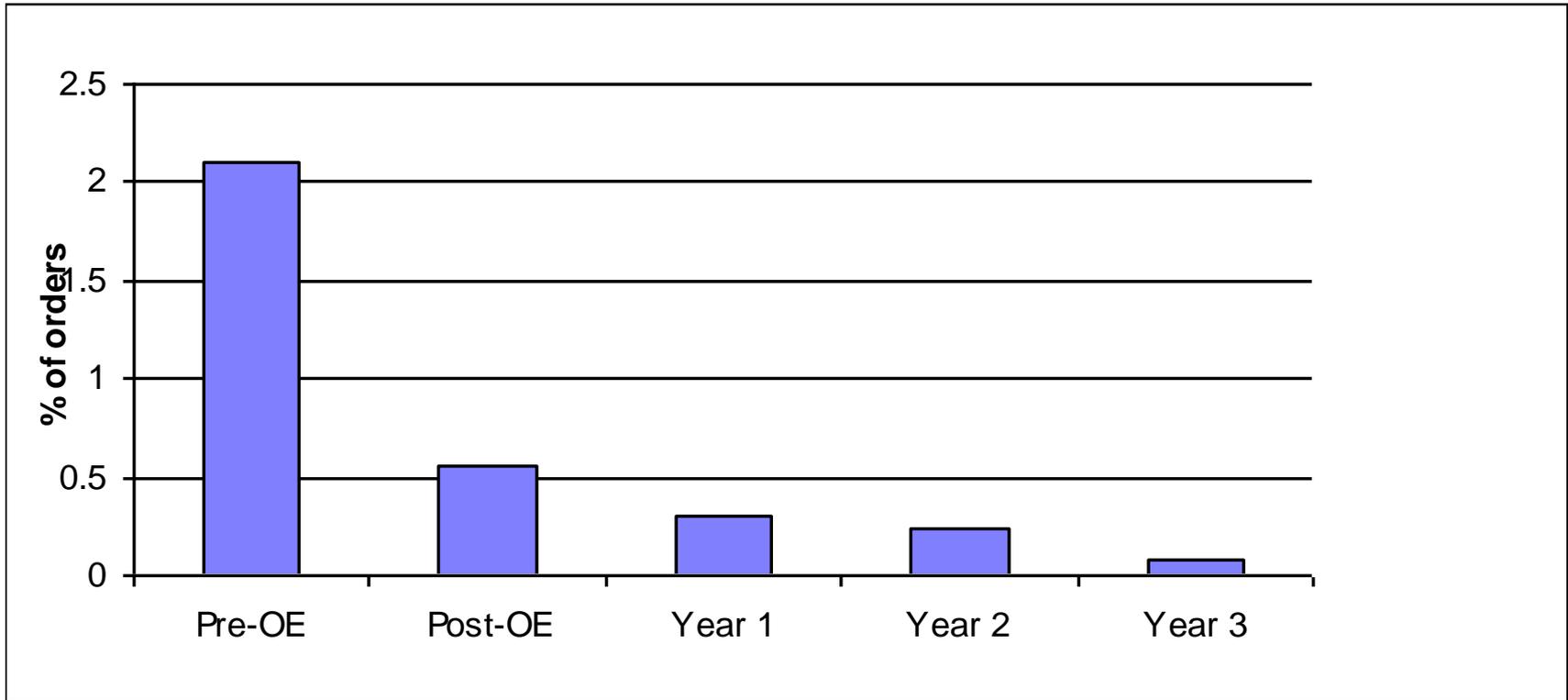
# Disclosure



- Elsevier provides management tools and content for order sets, care plans, clinical pathways, drug information, smart reference, analytics, and probably other stuff I don't even know about.
- This talk contains a few examples from Elsevier, some from the Brigham, and a lot from general sources.
- None of the material is intended to be commercial.

# Good CDS is good for healthcare

reduced dosing errors after implementing CDS with CPOE



# News seems to fluctuate

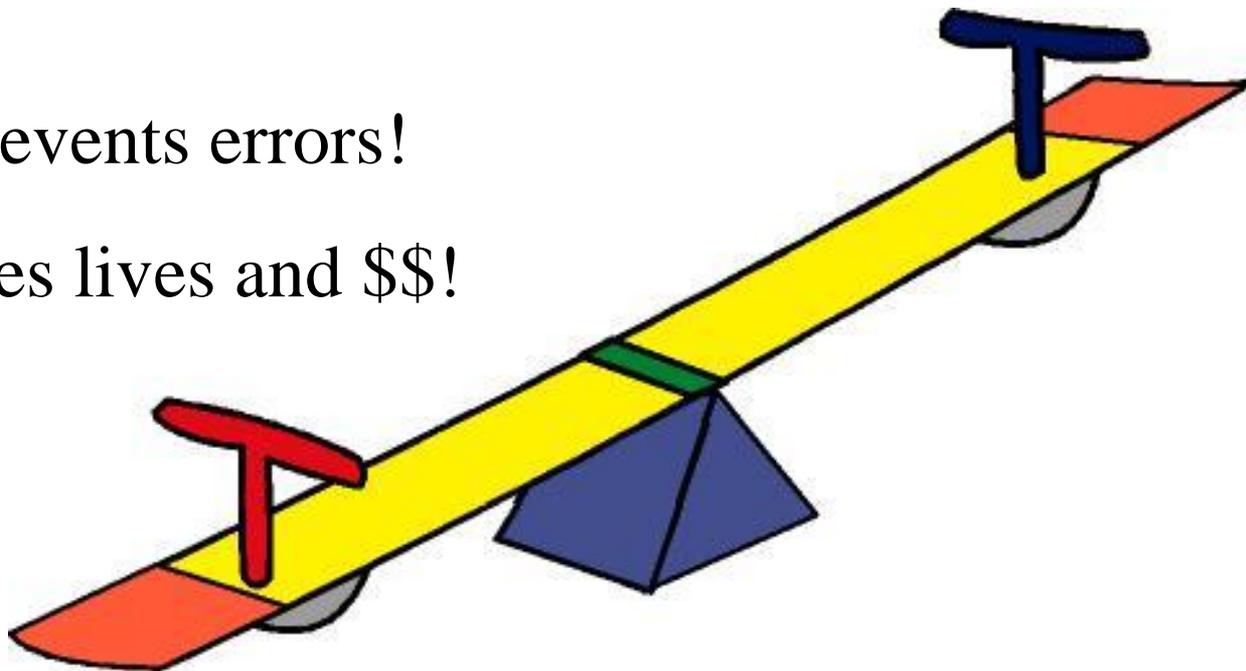


Causes errors!

Hurts patients!

Prevents errors!

Saves lives and \$\$!



# Grand Challenges (2008)



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



Journal of Biomedical Informatics 41 (2008) 387–392

Journal of  
Biomedical  
Informatics

[www.elsevier.com/locate/yjbin](http://www.elsevier.com/locate/yjbin)

## Grand challenges in clinical decision support

Dean F. Sittig <sup>a,b,\*</sup>, Adam Wright <sup>b,h</sup>, Jerome A. Osheroff <sup>c,d</sup>, Blackford Middleton <sup>e</sup>,  
Jonathan M. Teich <sup>f,g</sup>, Joan S. Ash <sup>b</sup>, Emily Campbell <sup>b</sup>, David W. Bates <sup>h</sup>

- Usability
- Share CDS artifacts (executable/readable)
- Provide CDS repositories
- Communicate best practice CDS
- Filter for co-morbidities
- Make use of free text information
- Learn new CDS from big data

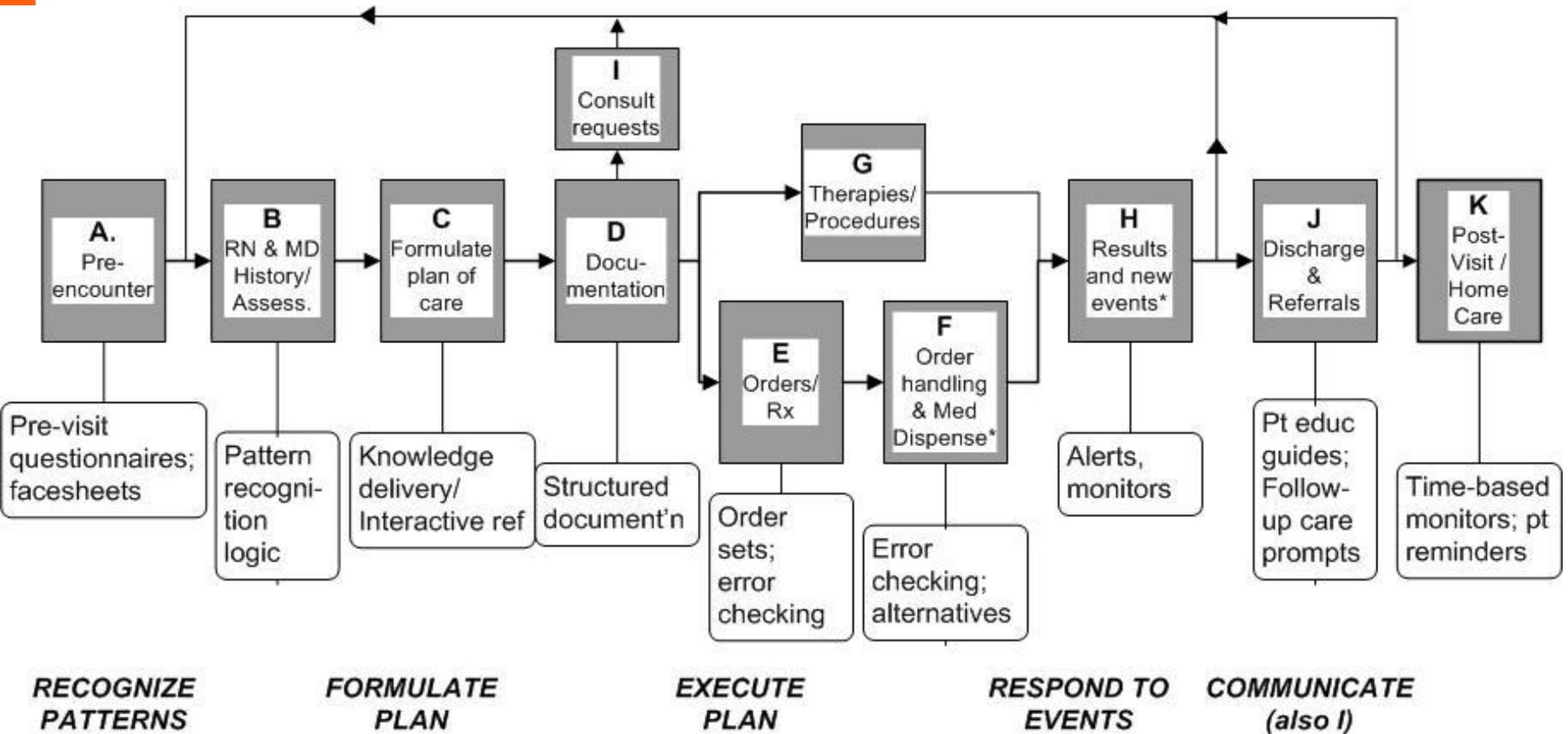


- Knowledge access
- Clinical pathways
- CDS sharing
- Back to the roots



# Knowledge Access

# Knowledge access





- At *Recognize* and *Formulate* time, it's about Q&A
  - Confirm things I know
  - Tell me about things I didn't know
  - Tell me about new things
- The “smart doc on my shoulder”:

# Understanding information needs and queries

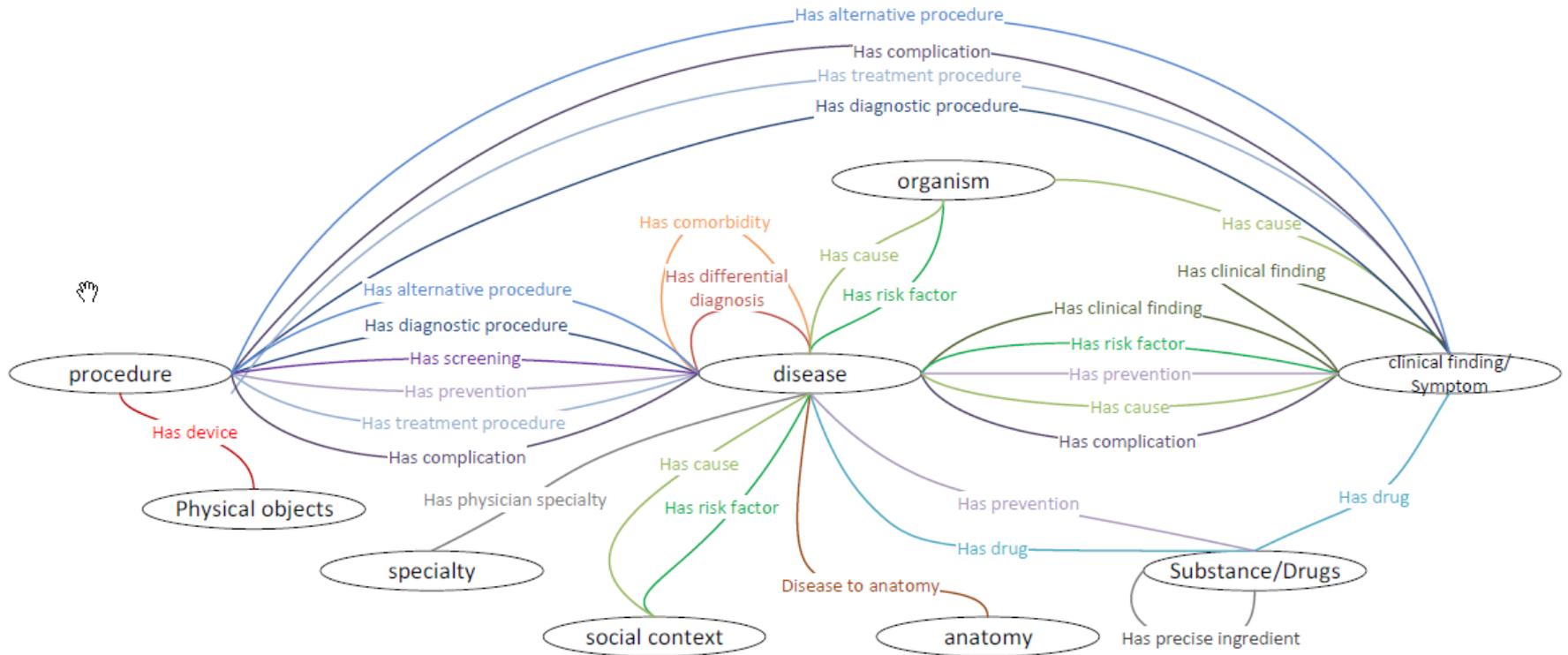
- 300,000 consecutive queries to MDConsult, ClinicalKey
- Synthesized ontology of information needs
- Agrees with and extends work of Ely et. al.

1	Sample search query	NEW: Mapping to standard question template	N
66	treatment of hyperhidrosis	How do I treat CONDX?	
67	atrial fibrillation anticoagulation	How effective is MED in the treatment of CONDX?	
68	(anemia) and diagnosis	How do I work up a patient with CONDX?	
69	(septic shock) and diagnosis	How do I work up a patient with CONDX?	
70	corticosteroids in bronchiolitis	How effective is MED in the treatment of CONDX?	B
71		How do I use MED in the treatment of CONDX?	B
72	"insulin pump therapy in children" and adolescents	How do I use MED in the treatment of CONDX?	D
73		How is OTHERTX used in the treatment of CONDX?	D
74	thrombolysis in myocardial infarction	How effective is MED in the treatment of CONDX?	A
75		How do I use MED in the treatment of CONDX?	A
76	indications for tpn	What are the risks and benefits of using OTHERTX in the treatment of CONDX?	N
77	deep brain stimulation for parkinson's disease	What are the risks and benefits of using OTHERTX in the treatment of CONDX?	P
78		How is OTHERTX used in the treatment of CONDX?	P

# Doctors only ask about 80 questions

59	How do I perform STUDY?								
60	What DX could cause lab test finding RESULT?								
61	<b>* Diagnosis: Differential Diagnosis (by Topic 1...2...n)</b>								
62	How do I distinguish CONDX from CONDX2...n?								
63	Compare DX1...DXn as the cause of OBS1...OBSn (differential diagnosis)								
64	What DXs could cause history finding OBS?								
65	What DXs could cause physical finding OBS?								
66	What DXs could be the cause of OBS1+...OBSn?								
67	What DX could cause lab test finding RESULT?								
68	<b>* Diagnosis: Consultation</b>								
69	In what circumstances should I obtain consultation in the workup of CONDX?								
70	<b>* Treatment: Summary Approach</b>								
71	What are the best treatment options for CONDX?								
72	How should I manage condition CONDX (not specifying diagnostic or therapeutic)?								
73	Compare MED1...MEDn (or med class 1...n) for treating CONDX								
74	Compare medical vs. surgical vs. other treatment for CONDX								
75	<b>* Treatment: Medications: (by Drug 1...2...n)</b>								
76	What is the best medication treatment for CONDX?								
77	How effective is MED in the treatment of CONDX?								
78	What is the dosing of MED?								
79	What are the side effects and adverse effects of drug MED, and how do I avoid/manage them?								
80	Are there contraindications to using MED?								

# Convert evidence → Knowledge graphs, triples

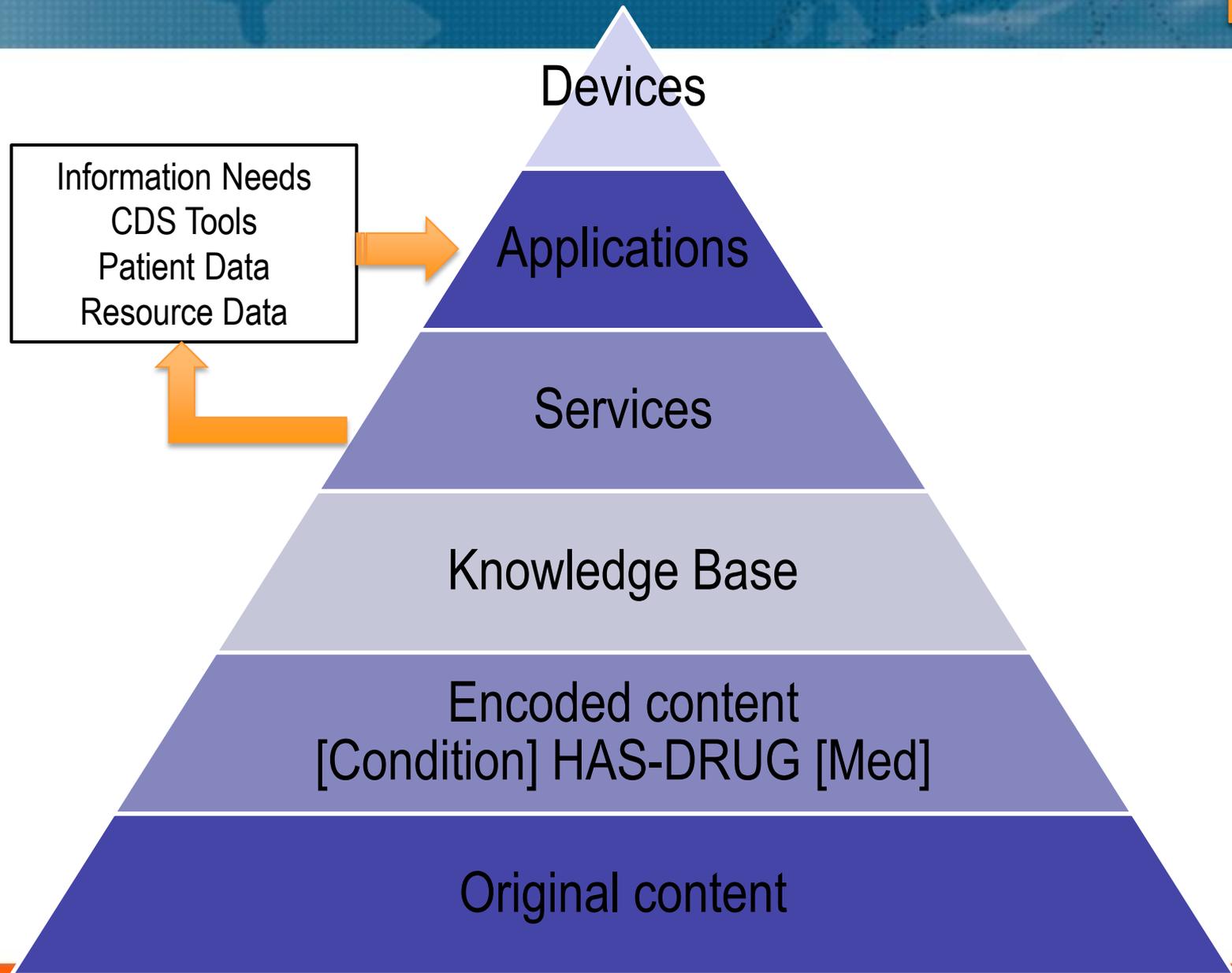


Strep pharyngitis

has drug  
SOE: 10 SOR: 9

penicillin

# Knowledge as a service tuned to need



# Precision Information to answer queries



Find an answer to:

Go

## ASSESSMENT Differential Diagnosis Syncope versus Seizures



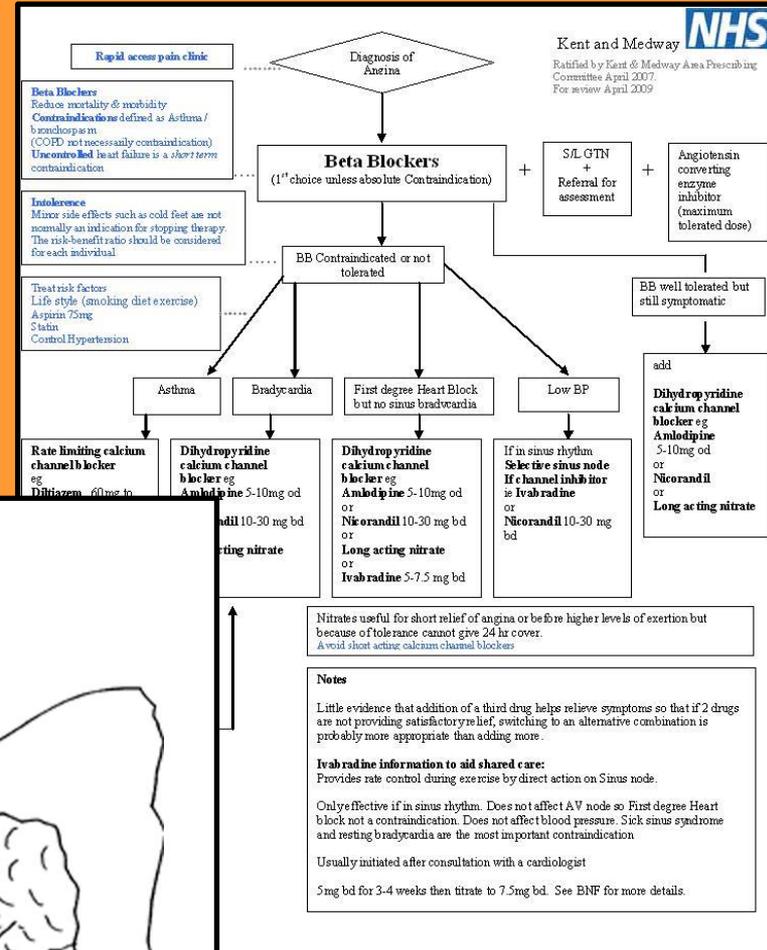
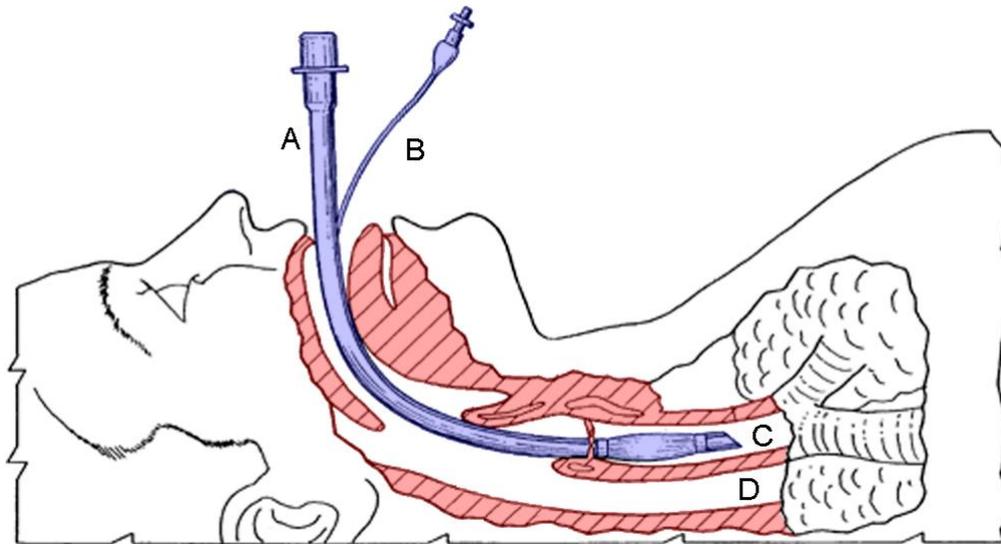
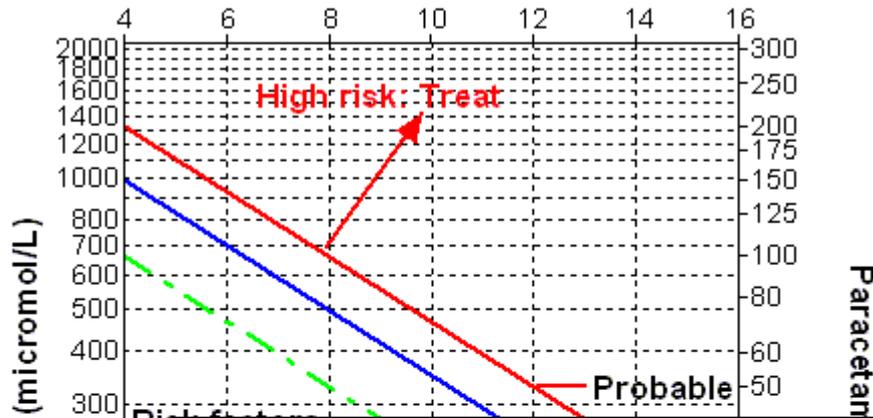
From Syncope

Source: [Comprehensive Hospital Medicine](#) (YEAR)

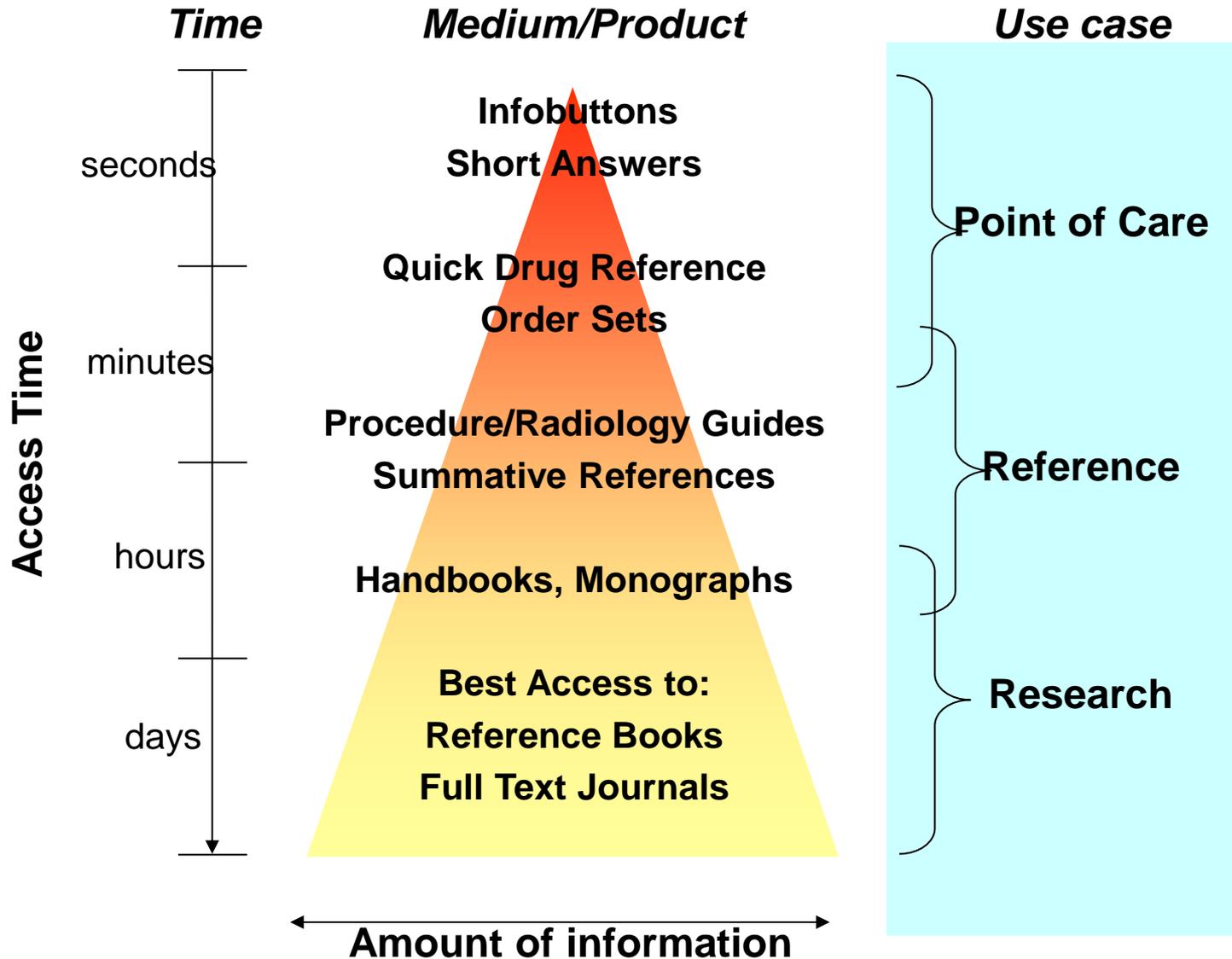
The differentiation between syncope and seizures is important, and it is not always obvious. Tongue biting or oral trauma, incontinence (especially fecal), lack of pallor or cyanosis, persistent tonic-clonic movements, slow return to consciousness, post event headache or confusion, or myalgias indicate seizures. Symptoms of nausea or diaphoresis prior to the event suggest syncope, whereas an aura (an auditory phenomenon, an upset stomach, complex visual experiences, or unpleasant olfactory sensations) is associated with seizures. Patients with syncope do not remember actually hitting the ground. Post event confusion has been described with syncope, but the confusion should not last more than 30 seconds. Seizure-like activity can occur with syncope (convulsive syncope) if the patient is held in an upright posture. However, convulsive syncope is not sustained and also rarely lasts longer than 30 seconds. Seizures generally last for at least 1-2 minutes. Seizures are associated with stertorous breathing and tachycardia, whereas syncope is usually associated with pallor and a slow, thready pulse.

# Knowledge in the right form

## Paracetamol nomogram



# Knowledge at the right depth



# There is precedent for converting knowledge to Q&A

Google

tylenol overdose symptoms



All

Shopping

Images

Videos

News

More ▾

Search tools

About 168,000 results (0.45 seconds)

## Symptoms of liver failure:

- Anorexia—no interest in eating.
- Nausea.
- Vomiting.
- Discomfort.
- Abdominal pain—especially in the upper-right portion of the abdomen.
- Excessive sweating.
- Jaundice.
- Confusion, sleepiness.

## Symptoms Acetaminophen Poisoning Conditions 197581

[health.cvs.com/GetContent.aspx?token=f75979d3-9c7c-4b16-af56...](https://health.cvs.com/GetContent.aspx?token=f75979d3-9c7c-4b16-af56...) CVS Pharmacy ▾

*About this result • Feedback*

## Acetaminophen Overdose: Symptoms & Treatment Options - Drugs.com

[www.drugs.com](https://www.drugs.com) > CareNotes ▾

Common signs and symptoms happen during each stage of an acetaminophen overdose. If the overdose is treated right away, you might have fewer or easier symptoms in the later stages. First 24 hours:

Nausea, vomiting, stomach pain, and loss of appetite.

“ How do I treat a pulmonary embolism ”

OK, here you go:

Input interpretation

pulmonary embolism and infarction	drugs prescribed at visit
-----------------------------------	---------------------------

Result

	male	female	all
coumarins and indandio: nes	34%	40%	38%
phenylpi:	0%	27%	22%



# Applications: Knowledge as surveillance

Schedule **Hope, Robert** ✕ Actionable Updates

**Hope, Robert**

DOB: 11-25-1974

Age/Gender: 35/M

Allergies: Penicillin G

Language: English

**Snapshot**

Results Review

Synopsis

Intake/Output

Problem List

History

Notes

Medications

Flowsheet

Order Review

Order Entry

Admission

Pre-transfer

Discharge

Rounding

Consult

Procedures

Discharge

**Actionable Updates**

[Heart failure patients taking losartan \(Cozaar\) 50 mg/day should be switched to 150 mg/day](#)

[Very low energy diet may improve ob](#)

**Demographics**

Mr. Robert A. Hope      Male - Age  
104 East 32nd Street      Tel 1: (51  
Cincinnati, OH 45044      Tel 2: (51

**Problem List**

Heart Failure [new dose](#)  
Hypertension, uncontrolled  
Rheumatoid Arthritis  
Sleep Apnea [new study](#)

**Reminders and Results**

- none -

**Heart failure patients taking losartan (Cozaar) 50 mg/day should be switched to 150 mg/day** ✕

Read Summary - Source: *BMJ* (3 Dec 2009)

Mr. Hope fits this criteria:

- ICD9 = 428.\*
- Med = losartan (Cozaar)
- Dosage = 50mg PO qd

FirstConsult topic: [Heart failure](#)

methotrexate 15mg/week [new med](#)

nitrofurantoin (macrocrystal-monohydrate)  
(MACROBID) capsule 100 mg

**Immunizations / Injections**

- none -

# Knowledge on rounds



Dr. Julius Hibert  
Settings

Rounds

Search



**Mike Roberts**

**Headache**

Venue **AMB**

Age, Sex **42 Male** Height **5'9"** Weight **240lbs**

Notable Conditions **Type 1 Diabetes**

Allergies **Penicillin**

## General

Migrane-type HA >72 hrs. give 250-500 cc D51/2 NS prior to neuroleptic administration and observed for potential orthostatic hypotension and acute extrapyramidal side effects. (JCSI 2009)

## Radiology

CT head no contrast (1) pt with HA and new abnl findings on neuro exam and/or suspicion of serious intracranial process (Level 2 ACEP 2008, JSCI 2009) OR (2) acute head trauma with sz (JSCI 2009)

CT head with contrast (1) any new sudden-onset severe HA (Level 2 ACEP 2008) OR (2) consider in HIV+ pt with new type of HA (Level 2 ACEP 2008)

## Medication



## New Related Information

In pellentesque faucibus vestibulum. Nulla at nulla justo, eget luctus tortor. Nulla facilisi. Duis aliquet egestas purus in blandit. Curabitur vulputate, ligula lacinia scelerisque tempor, lacus lacus ornare ante, ac egestas est urna sit amet arcu.

In pellentesque faucibus vestibulum. Nulla at nulla justo, eget luctus tortor. Nulla facilisi. Duis aliquet egestas purus in blandit. Curabitur vulputate, ligula lacinia scelerisque tempor, lacus lacus ornare ante, ac egestas est urna sit amet arcu.

ELSEVIER FIRST CONSULT | [READ MORE](#)

Patient-specific workup options:  
diagnostic and therapeutic choices



# Clinical Pathways

# Definition of a Clinical Pathway (Cochrane)

1. **Structured, multidisciplinary** plan of care
2. **Standardizes** care for a specific clinical problem or procedure
3. **Translates** guidelines or evidence into local action
4. **Shows all the care steps** in some structured form
5. **Advance to next step** at certain times or after certain events happen

Found in 80% of US hospitals



# Role in modern healthcare

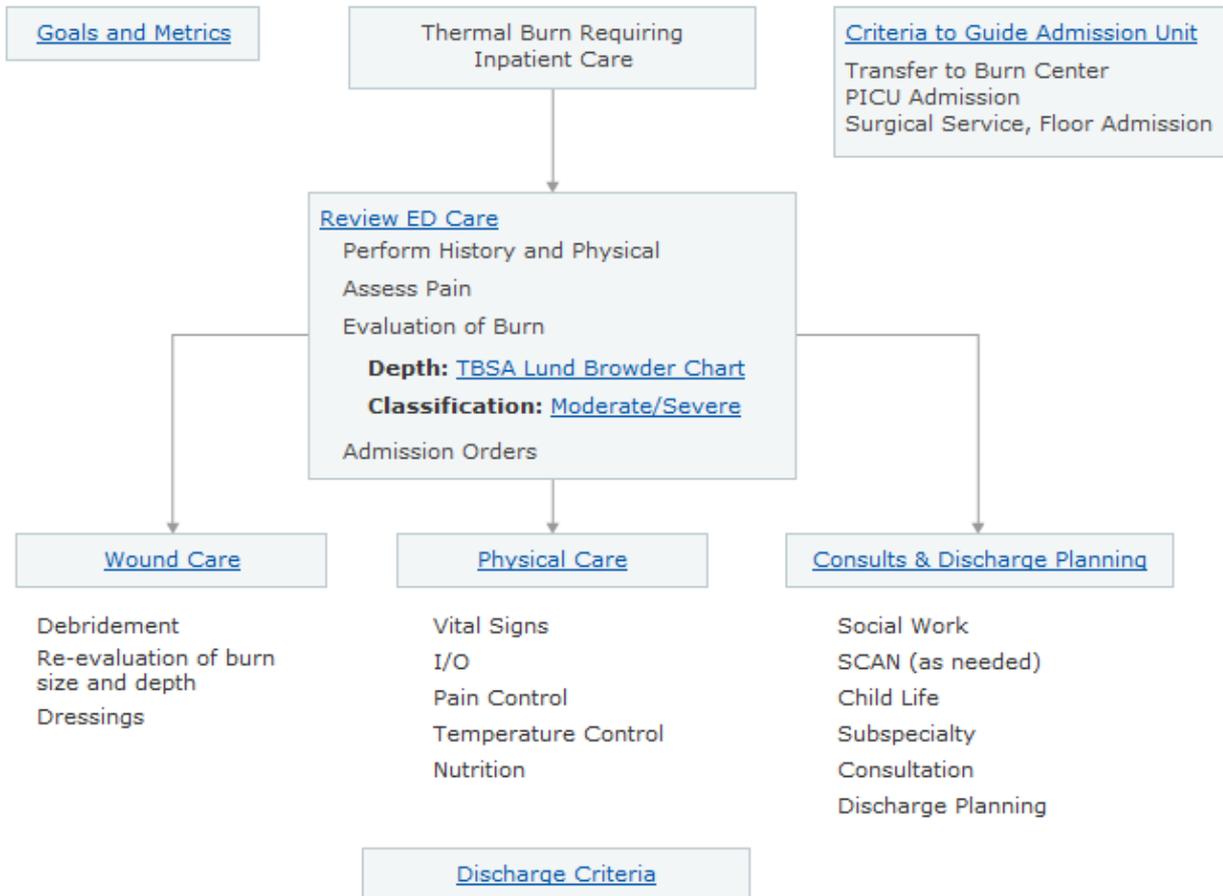
- Complex, chronic care
- Accountable care model – multi-site, multi-clinician, synchronized
- Standard care models, e.g., prenatal
- Acute inpatient protocols
- Under-resourced, developing countries



# Pathways can be multi-threaded

**Related Pathway:**  
[ED Burn Pathway](#)

## Inpatient Pathway for the Care of Children with Thermal Burns



### Learn More

[American Burn Association](#)

### Videos

[Trunk Burns Dressing](#)

[Hand Burns Dressing](#)

Source: CHOP

## Criteria to Assist in Determining Admission Unit

<b>Admit to Floor</b>	NO inhalation injury NO airway edema NO significant oral burns < 15% TBSA partial thickness burn (minor and moderate burns) NO hyperbaric oxygen treatment
<b>Transfer to Burn Center</b>	> 15% TBSA partial thickness or > 5% TBSA full thickness thermal burn (major burns) Severe electrical or chemical burn Potential need for grafting <a href="#">Consult with trauma</a>  and call Transport Communication Center at 4-2160 Chester-Crozer Burn Unit: 610-447-2800 St. Christopher Burn Center: 215-427-6900
<b>Admit to PICU</b>	Intubated, potential airway edema, potential inhalation injury, severe oral burns > 15% TBSA burns with delayed transfer to Burn Center due to instability or bed availability Other injuries requiring ICU care Hyperbaric oxygen treatment for elevated carboxyhemoglobin Severe pain requiring aggressive pain management

## Consults and Discharge Planning

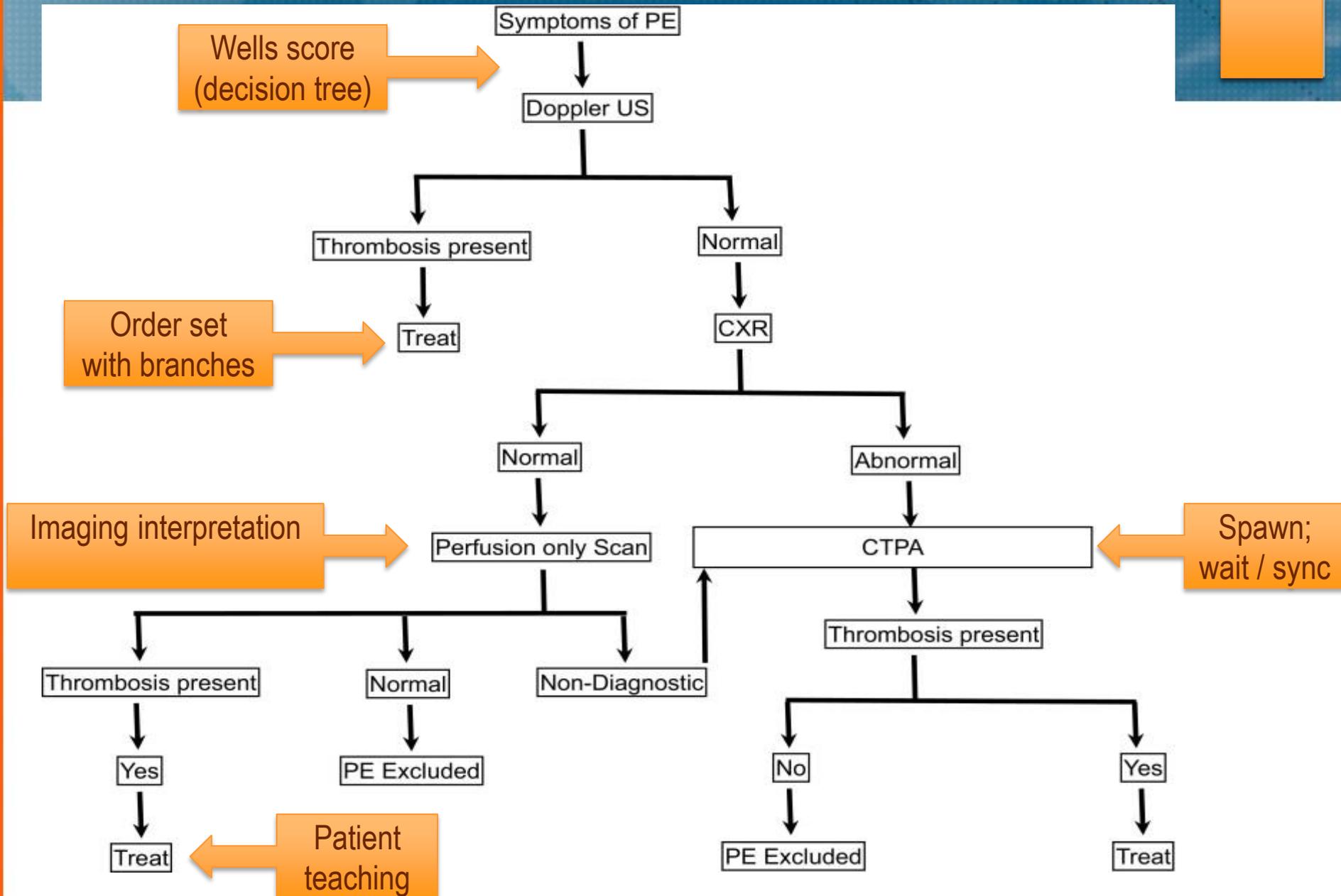
### Consults

<b>Social Work</b>	PRN for altered coping Lack of insurance Rule-out abuse
<b>SCAN Team if concern for abuse</b>	Patterned contact burns with insufficient history Cigarette burn Stocking, glove pattern to burn Mirror image burns of the extremities Symmetric burns on buttocks Immersion burn Multiple burn sites

### Subspecialty Consults

<b>Ophthalmology</b>	Burns in or near eyes
<b>Plastic Surgery</b>	Ear burns Full thickness burns that might need skin grafts
<b>Speech Therapy</b>	Oral burns
<b>Occupational and/or Physical Therapy</b>	Burns over joints Limited range of motion Possible splinting to prevent scar contractures
<b>Pain Team</b>	Opioid PCA

# Multi-step pathway with occasional CDS outputs





# CDS Sharing





*Episode IV*

## **A NEW HOPE**

*Roadmap for National Action on  
CDS*

*CDS Consortium*

*American Health Information  
Community*

*ONC CDS Expert Panel*

*Advancing CDS standards project*

*Health e-Decisions*

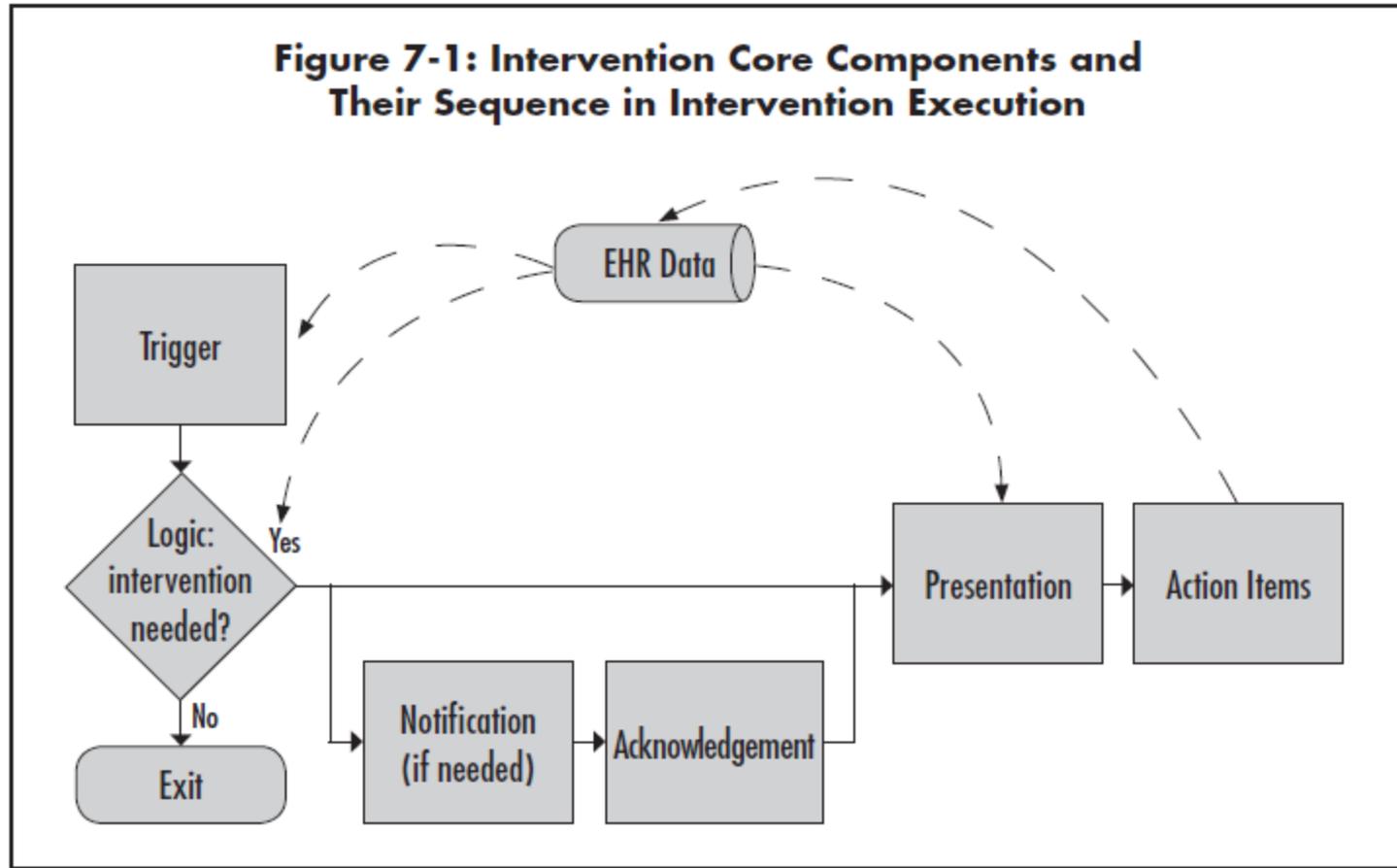
*CDS on FHIR*

# What I Want: The CDS Pyxis machine



- Disseminate
  - Standard format
- Select
  - By target, intervention type, setting
- Download
- Measure
- Collect Feedback

# Getting there: Standard CDS main components





## Trigger points

- Register
- ADT
- Observation
- Order start
- Med select
- Test result

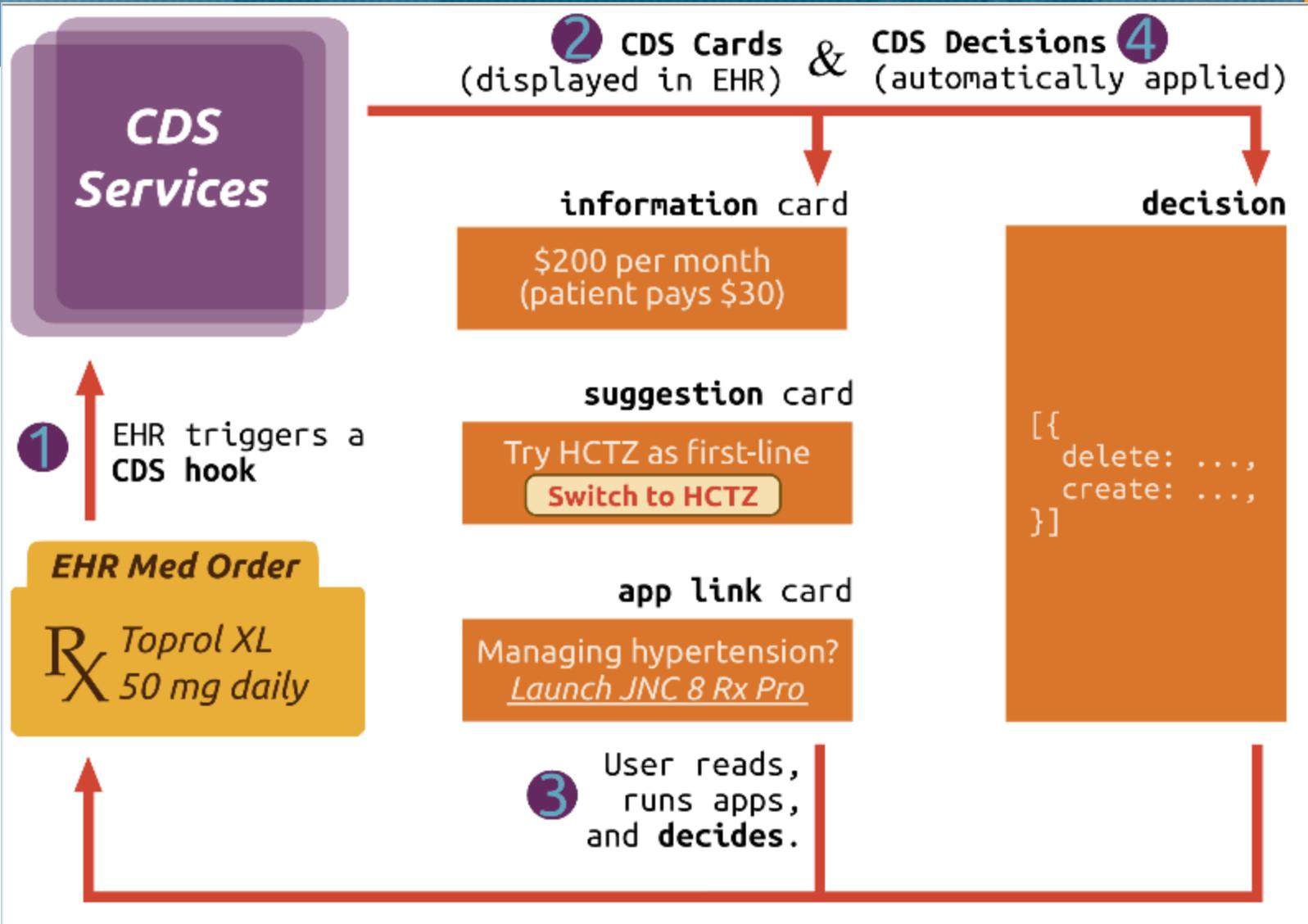
## Present'ns

- Alert
- Order set
- Smart Docu
- Advisory  
(infobutton)

## Actions

- New Order
- Del/Chg Order
- View info
- Post assertion
- Exception
- [Track]

# CDS on FHIR





- NAM Workgroup on CDS
  - Authoring
  - Distribution
  - Integration (EHR and workflow)
  - Technology
- A few companies springing up to connect CDS to any EHR
- The CDS Construction Kit
  - Type of health episode (well visit, chronic condition...)
  - Type of process (admit, communicate, discharge, order, print, administer)
  - Type of intervention, key parameters



## Other stuff

# Simple-to-build CDS



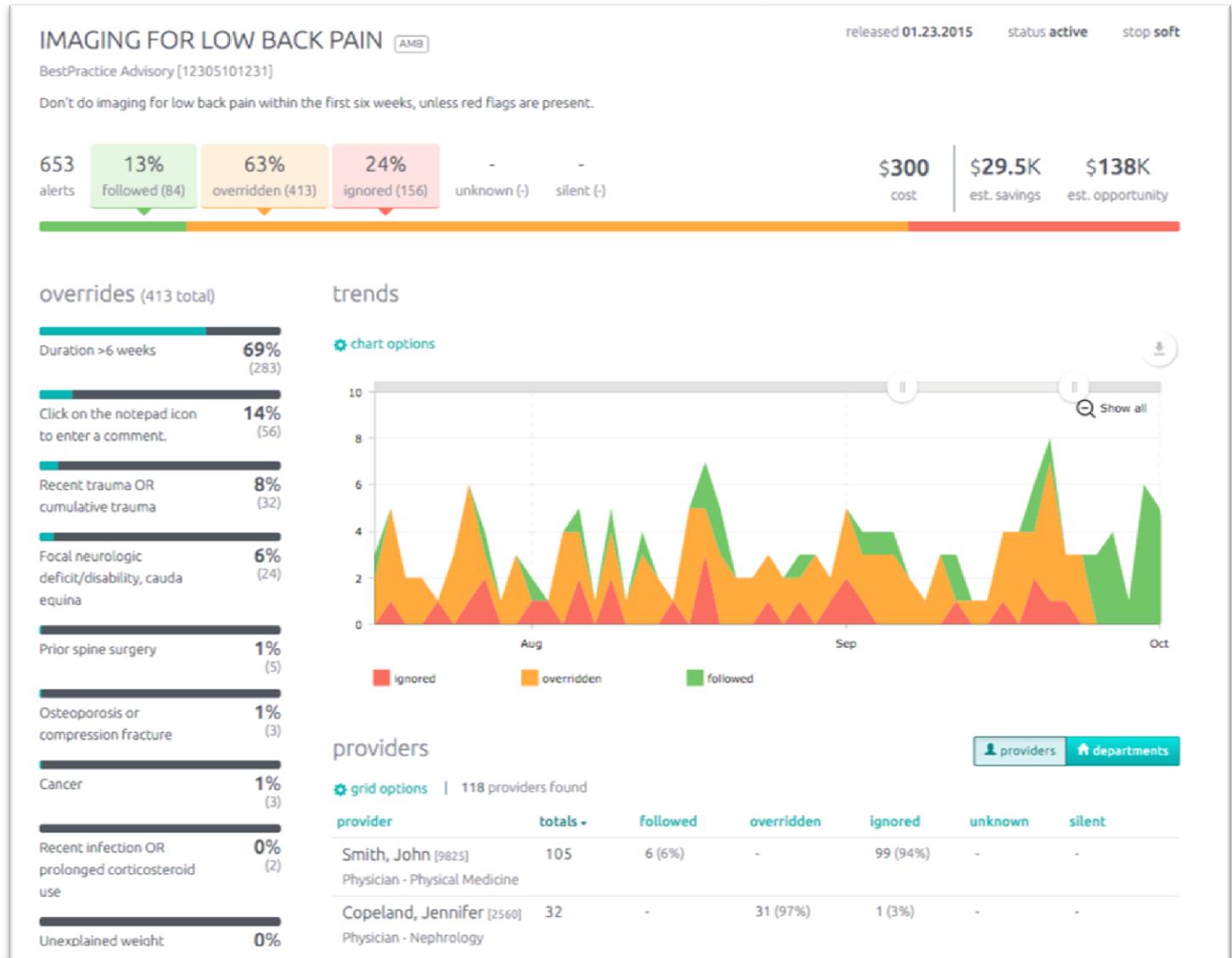
The screenshot shows the Herald CDS interface. On the left is a dark sidebar with the Herald logo, a user profile for Dr. Smith, and navigation options: 'Your Protocols', 'Create Protocol', and 'Share & Discover'. The main area is titled 'Your Protocols' and includes a search bar. Below this is a section for 'Active Protocols' with a table of three entries:

Protocol Name	Input	Condition	Output	Patient(s)	Status	Actions
Troponin elevation <small>Created 11.08.2015</small>	Troponin	More than 0.01	Page	BWH Cards B1	Active	<a href="#">View</a> <a href="#">Edit</a> <a href="#">Pause</a> <a href="#">Delete</a>
Hematocrit drop <small>Created 11.7.2015</small>	HCT	Less than prior by 3.0	SMS	MRN: 53135305	Active	<a href="#">View</a> <a href="#">Edit</a> <a href="#">Pause</a> <a href="#">Delete</a>
Radiology report finalized <small>Created 11.7.2015</small>	Rads	Has finalized	Email	MRN: 13478245	Disabled	<a href="#">View</a> <a href="#">Edit</a> <a href="#">Pause</a> <a href="#">Delete</a>

# How is your CDS doing?



Source:  
Stanson  
Health



# Patient-facing CDS



**myfitnesspal**

TUESDAY / Nov 17, 2009

### Your Daily Summary

**1569** CALORIES REMAINING

Goal	Food	Exercise	Net
2100	+1010	-479	531

**Add to Diary**

### Nutrient Summary

	Total	Goal	Left
Total Fat (g)	20	104	84
Saturated (g)	1	34	33

Home   My Diary   Progress   More



### Aspirin

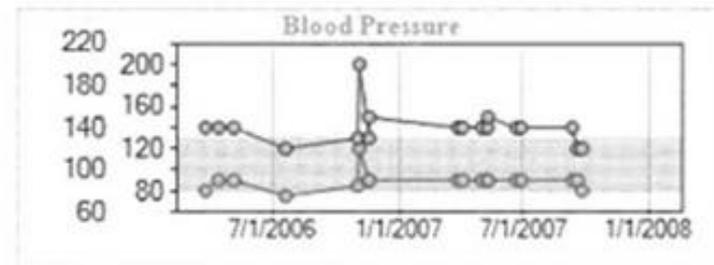
Because you have diabetes or heart disease, you might benefit from aspirin or another similar medication to prevent heart attacks and strokes, but there may be a good reason why your doctor has not prescribed it. Talk with your healthcare provider to find out if you should take aspirin regularly. Tip: Enteric-coated aspirin is effective and often safer than non-coated aspirin.

### Blood Pressure

On average, your blood pressure has been running high recently (average of 120/85 from your last two visits). The recommended blood pressure goal is 130/80. If your blood pressure medicine has not been recently adjusted or you are not on blood pressure medicine, you should talk with your provider about steps you can take to help lower your blood pressure.

### Urine Protein

People with diabetes have a higher risk of kidney



# Health surveillance

google.org Flu Trends

Language: English (United States)

[Google.org home](#)

Flu Trends

Select country/region

Home

[How does this work?](#)

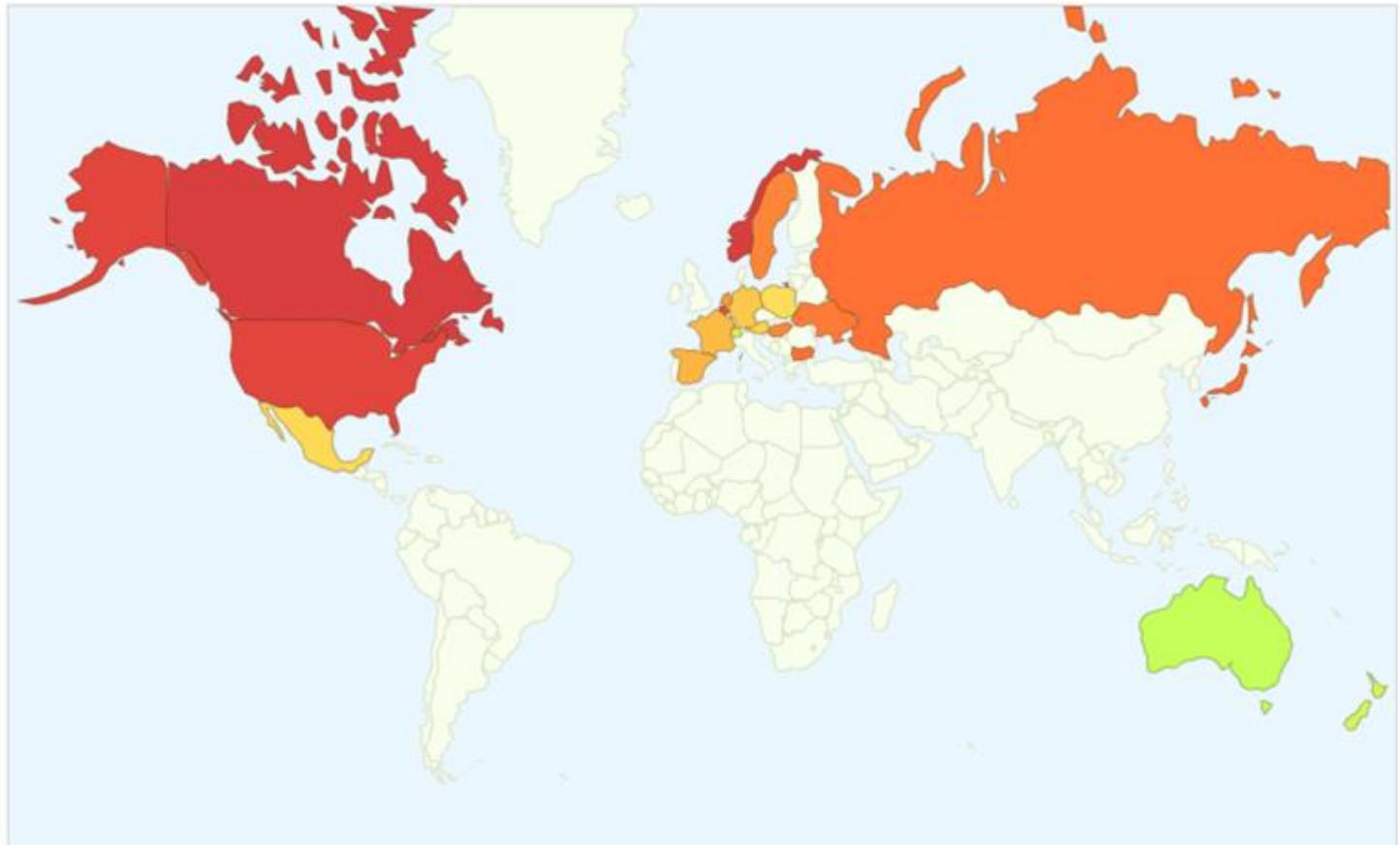
[FAQ](#)

Flu activity

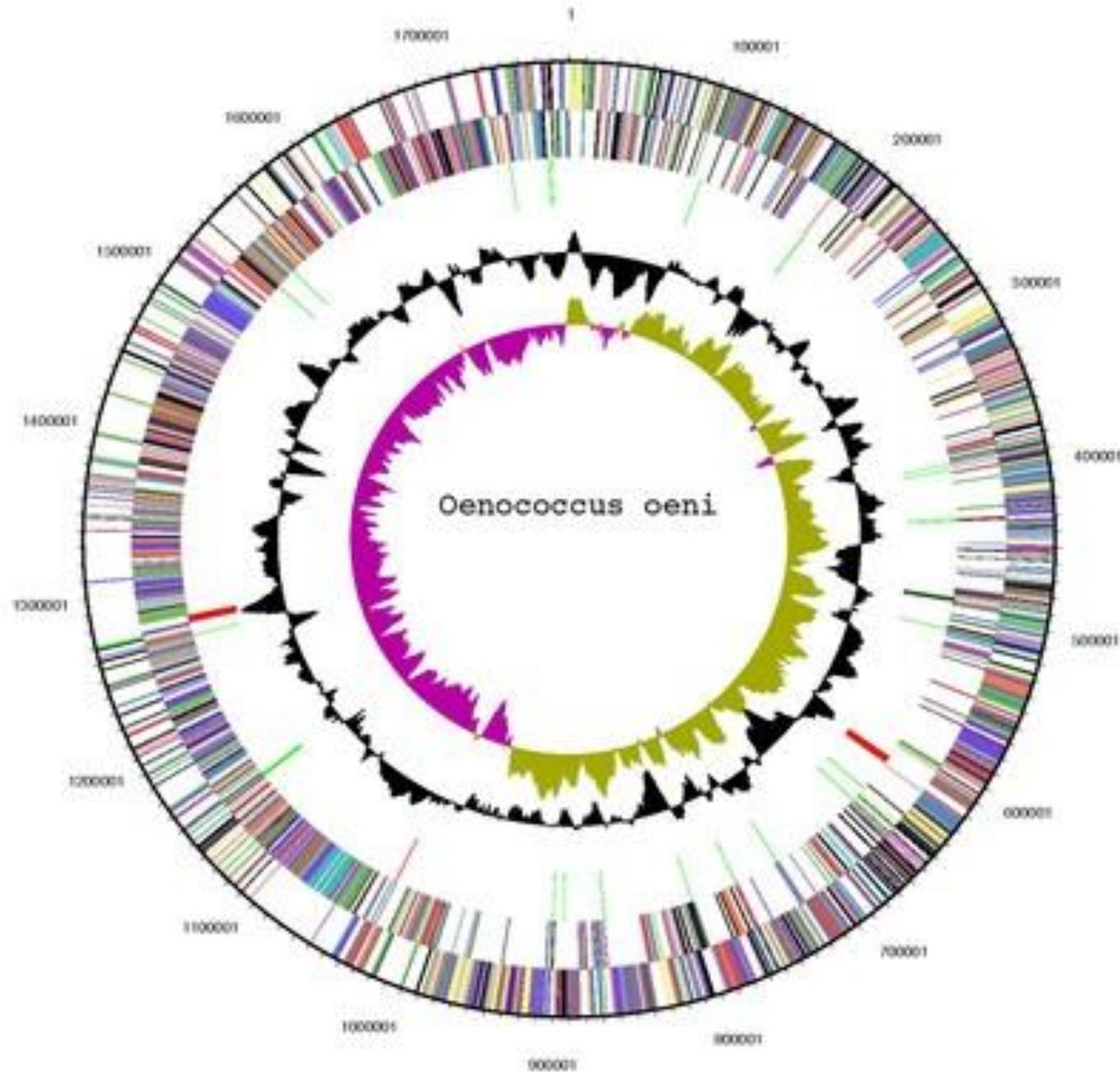
Intense  
High  
Moderate  
Low  
Minimal

## Explore flu trends around the world

We've found that certain search terms are good indicators of flu activity. Google Flu Trends uses aggregated Google search data to estimate flu activity. [Learn more »](#)



# Clinical genomics





# Back to our roots

# Smart documentation:



- “Hi doc, I have a problem”
  - “Have you ever had it before?”
  - “Do you also have this other relevant condition?”
  - “Do you have risk factors?”
  - “You might have X or Y”
  - “Here, this is the best treatment for your symptoms and for your problem”
    - I’ll give you this, You do that
  - “Let’s schedule something to find out more”

**CDS-driven smart documentation can make noting much better**

# What are the current grand challenges?



<b>Quick knowledge (Smart Doc)</b>	Deliver the most relevant info in a small, actionable package (mostly acute)
<b>Facilitate complex processes</b>	Simplify, optimize, keep track (pathways)
<b>Share CDS</b>	The CDS Pyxis machine – choose ‘n’ use <b>logic and operation.</b>
<b>Simple CDS building</b>	Lego blocks for the key components – for any CDS type. Teaching file of good examples
<b>Big data</b>	Focus: provide <b>filtered, highest priority</b> recommendations
<b>Monitor itself</b>	reduce fatigue by focusing on the important stuff
<b>Easy EHR</b>	Documentation and optimization bundles for conditions instead of E&M codes

# CDS is still the promise of HIT



As Chuck Friedman said:

