

# Keys to Successful Computerized Clinical Decision Support SINI 2007

Laura Heermann, RN PhD

Director of Nursing Informatics

Intermountain Healthcare

Salt Lake City, Utah

# Objectives

- Articulate the importance of Computerized Clinical Decision support in healthcare
- Identify different types of Clinical Decision Support Systems (CDSS)
- Understand the basic process of developing a CDSS
- Understand the challenges of implementing CDSSs

# What are Clinical Decision Support Systems?

- Any computer program designed to help healthcare professionals make clinical decisions (*EH Shortliffe, 1990*)
- A system consisting of a knowledge base and an inference engine that is able to use entered data to generate advice (*J.H. Van Bommel and M.A. Musen, 1997*)

# What else can a CDSS do?

- Aid and strengthen decision making and overall efficiency

*Semples, 1996*

- Organize information to fit new environments
- Provide analysis and advice to support a choice
- Leave the final decision with the practitioner

*Hebda, Czar, Mascara, 1998*

# Key Functions

- Clinical Decision Making
  - Supporting clinical diagnosis and treatment plan processes; and promoting use of best practices, condition-specific guidelines, and population-based management.
- Managing clinical complexity and details
  - Keeping patients on research and chemotherapy protocols; tracking orders, referrals follow-up, and preventive care.
- Administrative
  - Supporting clinical coding and documentation, authorization of procedures, and referrals.
- Cost control
  - Monitoring medication orders; avoiding duplicate or unnecessary tests.

*Perreault & Metzger (1999). A pragmatic framework for understanding clinical decision support. Journal of Healthcare Information Management. 13(2):5-21.*

# Why Consider Using a CDSS?

- Clinicians cannot keep up with rapidly changing and increasing body of clinical knowledge
- Human error occurs in both routine and complex cases
  - DSS tools can supply alerts and/or reminders regarding possible concerns or omissions

# Ultimately . . .

“It is simply unrealistic to think that individuals can synthesize in their head scores of pieces of evidence, accurately estimate the outcomes of different options, and accurately judge the desirability of those outcomes for patients.... All confirm what would be expected from common sense: The complexity of modern medicine exceeds the inherent limitations of the unaided human mind.”

*Eddy, DM. Clinical Decision Making. JAMA 1990;263:1265-1275*

# The Numbers...

Clinical complexity = > 236 at  
one “average” ICU bedside

The ventilator alone:  
50 controls x Multiple settings =  
> 37 BILLION Choices!

Average # of variables the human brain can remember = 7



# Benefits of a CDSS

- Efficient decision making
- Can provide a competitive edge
- Standardizes care
- Facilitates the move to managed care
- Manages data effectively and efficiently
- Provides historical and current data reports

*Hebda, Czar, Mascara (1998) and Van Bommel & Musen (1997)*

# Benefits of a CDSS

- Reduction in medical errors and improvement in quality
  - Potentially dangerous situations are detected quickly and brought to the attention of the caregiver, thus avoiding undesirable patient outcomes.
- Potential reduction in long term costs
  - As quality improves, complications that could result in greater costs down the road are avoided. Also the risk of malpractice suits is reduced.

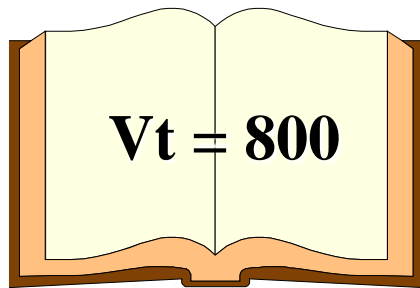
Arsala, Rosenblatt, Singer & Slouffman (2005), Source:

<http://www7.kellogg.northwestern.edu/techconcepts/winter2005projects/healthcaresoftware/cdss2.htm>

# Decision Support Tools



# Cookbook: Post Op Adult Males



$VT = 800$

$VR = 15$

Peak Flow = 60 l/m

$FiO_2 = 40\%$

Designed for patient groups...

NOT the individual patient

# Guideline



11.5.1 Increases in  $P_{aw}$  may result in improved oxygenation; however,  $P_{aw} > 12$  cm H<sub>2</sub>O has been associated with barotrauma

11.5.4 PEEP increases FRC and may improve oxygenation and ventilation-perfusion relationship (PEEP is typically adjusted at 4-7 cm. H<sub>2</sub>O levels beyond this range may result in hyperinflation)

*Neonatal time triggered, pressure limited, time-cycled mechanical ventilation, AARC Clinical Practice Guideline. Respir Care 1994; 39(8): 808-816*

# Carepath



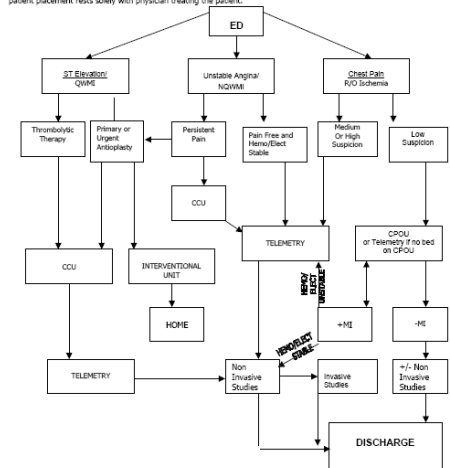
Post Op thoracic surgery patients should be weaned within 24 hours

- Focused on patient group rather than individual patient
- Heavily oriented towards resource management

## ACUTE CORONARY ISCHEMIA CLINICAL PATHWAYS

### PHYSICIAN REFERENCE GUIDE

This reference sheet serves as a general guideline for patient care. It indicates acceptable placement of patients with possible or actual acute coronary ischemic syndromes within the institution. The responsibility however for decisions regarding patient placement rests solely with physician treating the patient.



# Clinical Protocols

Decrease PEEP in increments of 2-3 accepting  $PO_2 > 85$  unless otherwise stated by physician

...patient will receive a tidal volume of approximately 10-12 ml/Kg ideal body weight. Morbidly obese patients may have tidal volumes set at 5 ml/Kg actual body weight. Note: High tidal volumes at 12-15 ml/Kg in ARDS may contribute to an increased risk of barotrauma

*Darin, J: Procedure 10.02, pg 7, Mechanical Ventilation Protocol Heritage Hospital, Taylor, MI in the AARC Critical Care Protocol Library Set PC1 1995*

# Specific Executable Protocols

Increase PEEP by 2 cm H<sub>2</sub>O  
from 8 to 10 cm H<sub>2</sub>O.

Maintain FiO<sub>2</sub> = 70%

Maintain VT set = 500 ml

Increase Rate set by 2 from 28 to  
30 breaths/min

Adjust Peak Flow to maintain I:E  
near 1:2.3

Draw an ABG 20 min after vent  
change

Clear & Concise

No Weasel Words



# CDSS Tools Used in Clinical Tasks

- Information Retrieval
- Alerting and Reminders
- Therapy Critiquing, Planning and Prescribing
- Image Recognition and Interpretation
- Retrospective analysis and quality assurance
- Diagnostic Assistance and Suggesting

Coiera (2003). *Guide to Health Informatics: 2<sup>nd</sup> Ed.* Source: <http://www.coiera.com/aimd.htm>

Haug, P.J, Gardner, R.M, Evans, R.S (1999). *Hospital Based Decision Support Systems; Clinical Decision Support Systems; Springer-Verlag, Inc.*

# Information Retrieval

- Software 'agents' can search for and retrieve information to answer clinical questions.
- Intelligent information retrieval systems can:
  - Assist in formulating accurate clinical questions.
  - Act as information filters.
  - Assist in identifying appropriate sources of evidence.

The top screenshot shows a web browser window with the URL <http://www.clineguide.clineguide.com/?Caption=80&LinkContext=12444%7C5%7C252&...>. The page is titled 'creatinine, serum > high' and features a 'Clinical significance' section with the following bullet points:

- Used to monitor renal function:
  - in established renal disease
  - in diabetes
  - with use of potentially nephrotoxic drugs (eg, NSAIDs, ACE inhibitors, lithium )
  - during dialysis.
- An elevated creatinine is a marker of a primary pathology (see causes).
  - 50% loss of renal function is needed to increase serum creatinine from 1.0 to 2.0

The bottom screenshot shows the 'HELP2 Clinical Desktop (Version 2006.2.51)' interface. The 'Report Manager' section is active, showing a list of reports with checkboxes for selection. The reports listed are:

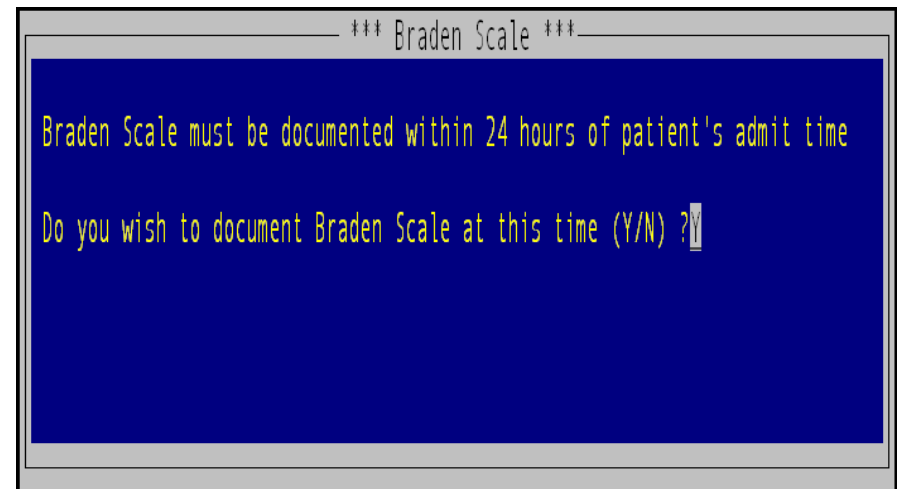
- Care Managers
- Clinician
  - Patient Worksheet
- Glucose Protocol Patients
  - Cross Patient Summary Report (48 Hrs Time Range)
  - Decision Support Summary Report
- Growth Charts
  - Height Weight Chart

The interface also includes a 'Select Patient' sidebar, a 'Report Manager' section with 'View' and 'Print' buttons, and a status bar at the bottom showing 'JODE A. Temp Provider Lake Park IHC Timeout Status: Fri Oct 20, 2006 13:46'.

# Alerting & Reminders

Test Status	Na	K	Cl	CO2	Anion Gap (Na Cl CO2)	Glucose	BUN	Creatinine	Ca
	137-146 mmol/L	3.5-5.0 mmol/L	98-109 mmol/L	19-30 mmol/L	3-16 mmol/L	65-99 mg/dL	6-21 mg/dL	0.8-1.3 mg/dL	8.4-10.2 mg/dL
Final	137	4.1	107	23	7	106 H	36 H	1.6 H	8.2 L
Final	139	3.7	109	24	6	100 H	36 H	1.6 H	8.5

- Function continuously
- Monitor clinical data  
“behind the scenes” as it is entered into the patient’s record
- Designed to test specific types of data against pre-defined criteria



# Critiquing & Suggesting

- Begin with the entry of an intervention order into the system
- Evaluate the order
- Point out disparities between the order and an internal definition of proper care or propose an alternative approach
- System responds with concrete suggestions concerning which actions to take next
- Processes are designed to react to requests for assistance

## IHC ANTIBIOTIC ASSISTANT &amp; ORDER PROGRAM

827

253 60yr F Dx:FEVER HYPOXIA

» Max 24hr WBC=28.1↓(28.9) Admit:03/09/00.20:49 Max 24hr Temp=37.3↓(38.1)  
 Patient's Diff shows a left shift, Max 24hr Bands=11↑( 5)  
 » RENAL FUNCTION: Decreased, CrCl = 76, Max 24hr Cr= .6→( .6) IBWeight: 56kg  
 » ANTIBIOTIC ALLERGIES: None reported  
 » CURRENT ANTIBIOTICS:  
 1. 03/10/00 7days LEVOFLOXACIN (LEVAQUIN), PIGGYBACK 500. Q 24 hrs  
 2. 03/10/00 7days IMIPENEM/CILASTATIN (PRIMAXIN), VIAL 500. Q 6 hrs  
 » IDENTIFIED PATHOGENS SITE COLLECTED  
 Yeast Endotrachial 03/13/00.09:41  
 Candida albicans Endotrachial 03/13/00.09:41

THERAPEUTIC SUGGESTION	DOSAGE	ROUTE	INTERVAL
Imipenem	500mg	IV	*q8h (infuse over 1hr)
Fluconazole	400mg	IV	q24h (800mg load)

Suggested Antibiotic Duration: Until pat. condition suggests other therapy.  
 \* Adjusted based on patient's renal function.

<1>Micro, <2>OrganismSuscept, <3>Drug Info, <4>ExplainLogic, <5>Empiric Abx,  
 <6>Abx Hx, <7>ID Rnds, <8>Lab/Abx Levels, <9>Xray, <10>Data Input Screen,  
 <Esc>EXIT, <F1>Help, <0>UserInput, <.>OutpatientModels, <+orF12>ChangePatient  
 ORDER:<\*>Suggested Abx, <Enter>Other Abx, </>D/C Abx, <->Modify Abx, █

Mon Jul 17 09:47

ICIS v4.1p17u0

User: RICK

SAPS Test 2

8 76 54 32

Login

Logout

Census

Patient

Config

Utility

SERVICE: CCU

100.0

07/04/95

TEST 4

ATTENDING:

kg-dry

HOSP ADMIT

UNIT ADMIT

UNIT BED

Sections:

Flowsheet

Labs

Micro

Notes

Medications

Respiratory

MD Review

Trial

ARDS Trial

Forms:

ARDS data

Pending

History

Logic Trace

Protocol Instructions

07/17/95  
09:46

Pending Action

\*\* THE FOLLOWING INSTRUCTIONS WERE ACCEPTED AND HAVE NOT BEEN FOLLOWED. \*\*

07/17/95  
09:46

Pending Action

Increase FiO2 by 10.0 from 70.0 to 80.0 %.

07/17/95  
09:46

Pending Action

Increase PEEP by 2.0 from 5.0 to 7.0 cm/H2O.

07/17/95  
09:46

Pending Action

EITHER DECLINE ABOVE INSTRUCTIONS OR ACCEPT AND CHART CORRECT SETTINGS BEFORE RUNNING PROTOCOL.  
\*\*\*\*\*

New Data

F1:

F3:

F5:

F7:

F9:

F11:

F2:

F4:

F6:

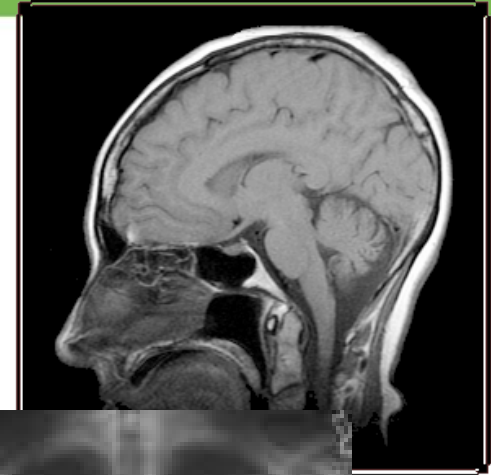
F8:

F10:

F12:

# Image Recognition & Interpretation

Images can be screened and flagged for detailed human attention.



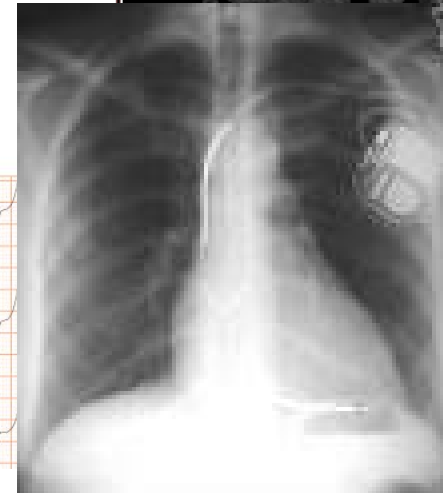
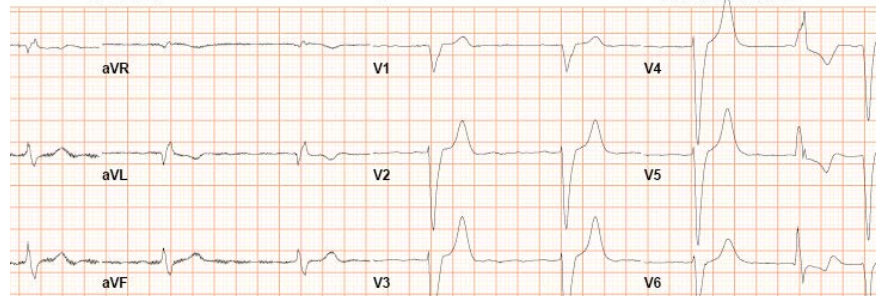
Vent. rate	53	BPM	Wide QRS rhythm with occasional Ventricular premature complexes
PR interval	*	ms	Bizarre axis (-90 to -180)
QRS duration	138	ms	Non-specific intra-ventricular conduction block
QT/QTc	444/416	ms	Abnormal ECG
P-R-T axes	* 102	93	When compared with ECG of 11-OCT-2006 15:24, Accelerated ventricular rhythm (50-100/min) has replaced Atrial fibrillation

J9  
ER OFF

NOTIFIED:

Referred by: D BURTON

Confirmed By: DAVID RAWLING, M.D.  
READING MD.PANEL

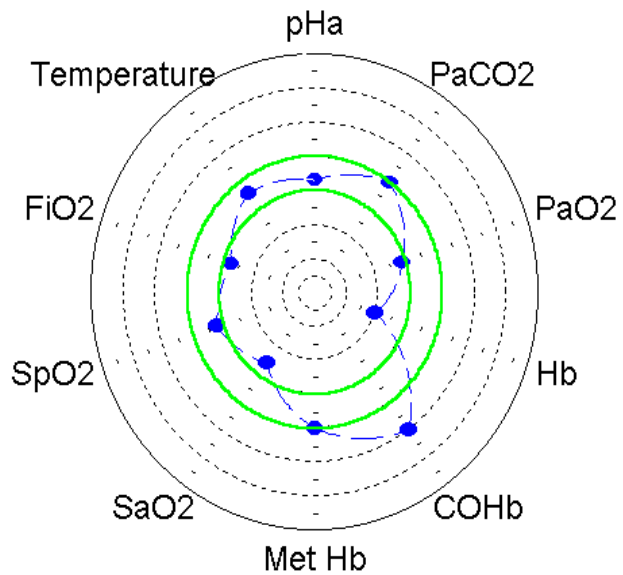


# Retrospective Review

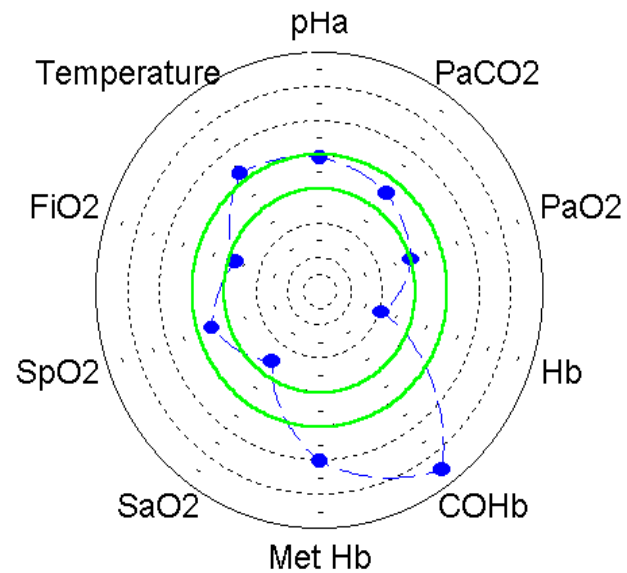
- Emphasizes computer's ability to collect and present a variety of information
- Reports can be of individual actions or patients, or aggregated across patients or clinicians
- Used most often in quality assurance activities or process improvement projects



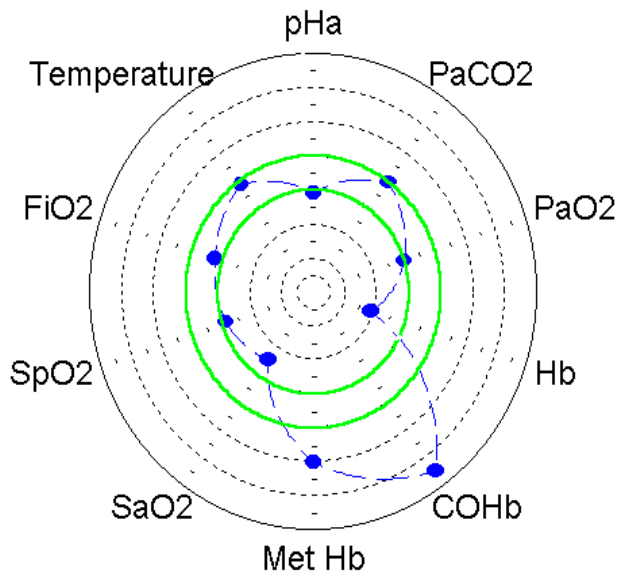
04/03/95 05:35



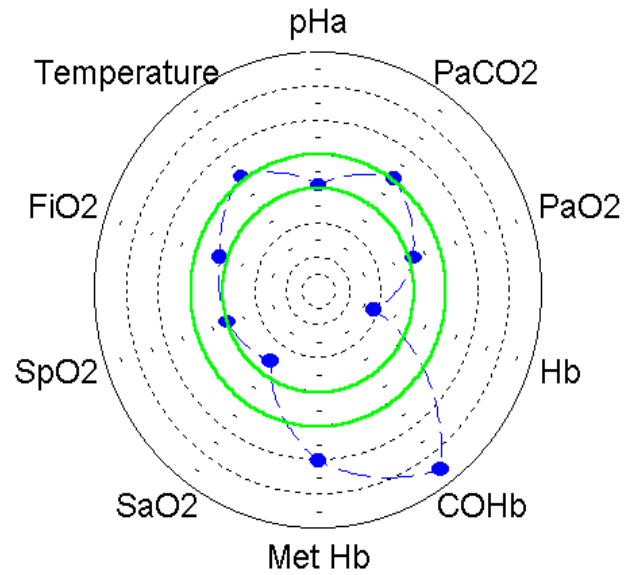
04/03/95 07:16



04/03/95 09:03



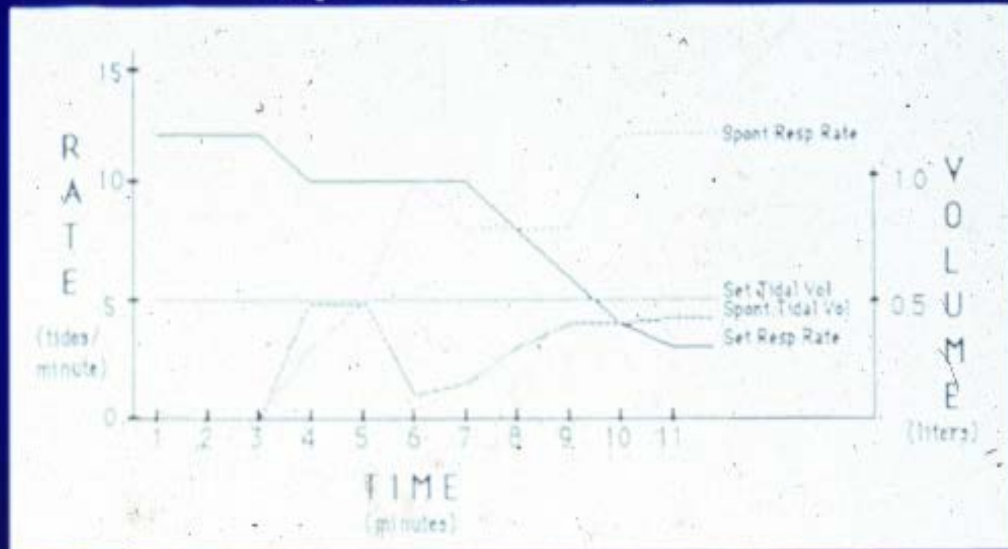
04/03/95 16:46



## Numerical Data

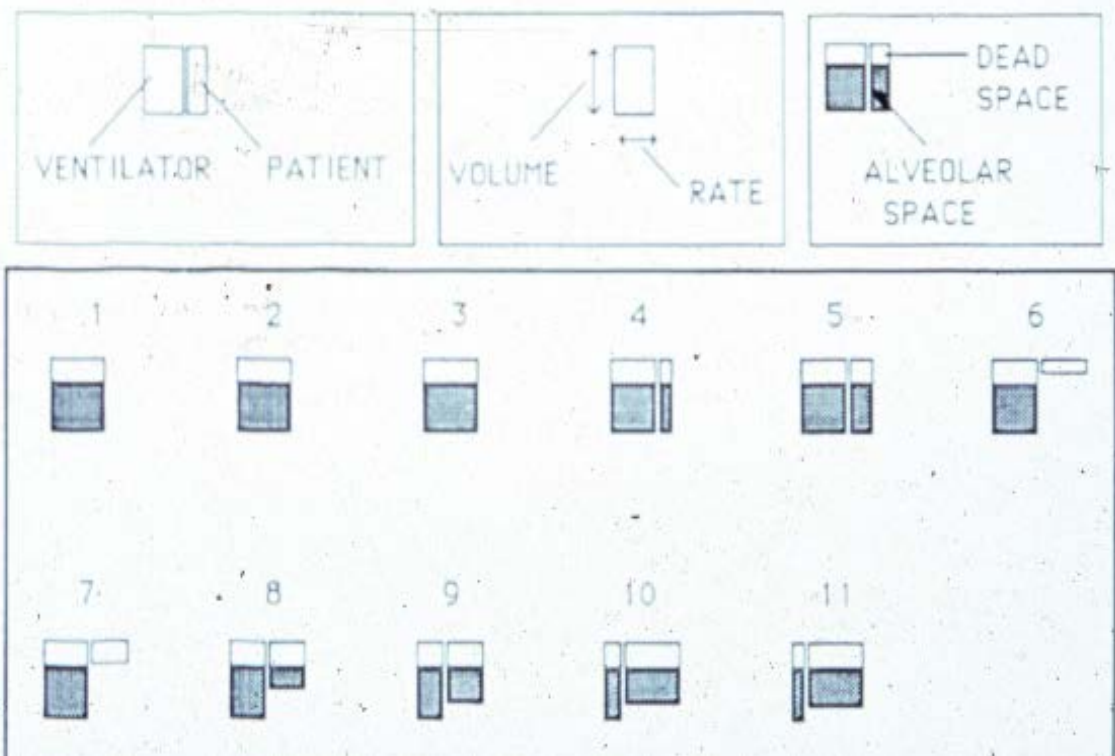
Minute #	Ventilator		Patient	
	Set Rate	Set Volume	Spont Rate	Spont Volume
1	12	0.50	0	0.00
2	12	0.50	0	0.00
3	12	0.50	0	0.00
4	10	0.50	3	0.50
5	10	0.50	5	0.50
6	10	0.50	10	0.10
7	10	0.50	8	0.15
8	8	0.50	8	0.30
9	6	0.50	8	0.40
10	4	0.50	12	0.40
11	3	0.50	12	0.42

## Simple Graphical Representation



## Metaphor Graphics

Cole WG, Stewart JG.  
 Metaphor graphics to support  
 integrated decision making  
 with respiratory data.  
 Int J Clin Monit and Comp  
 1993;10(2):91-100.

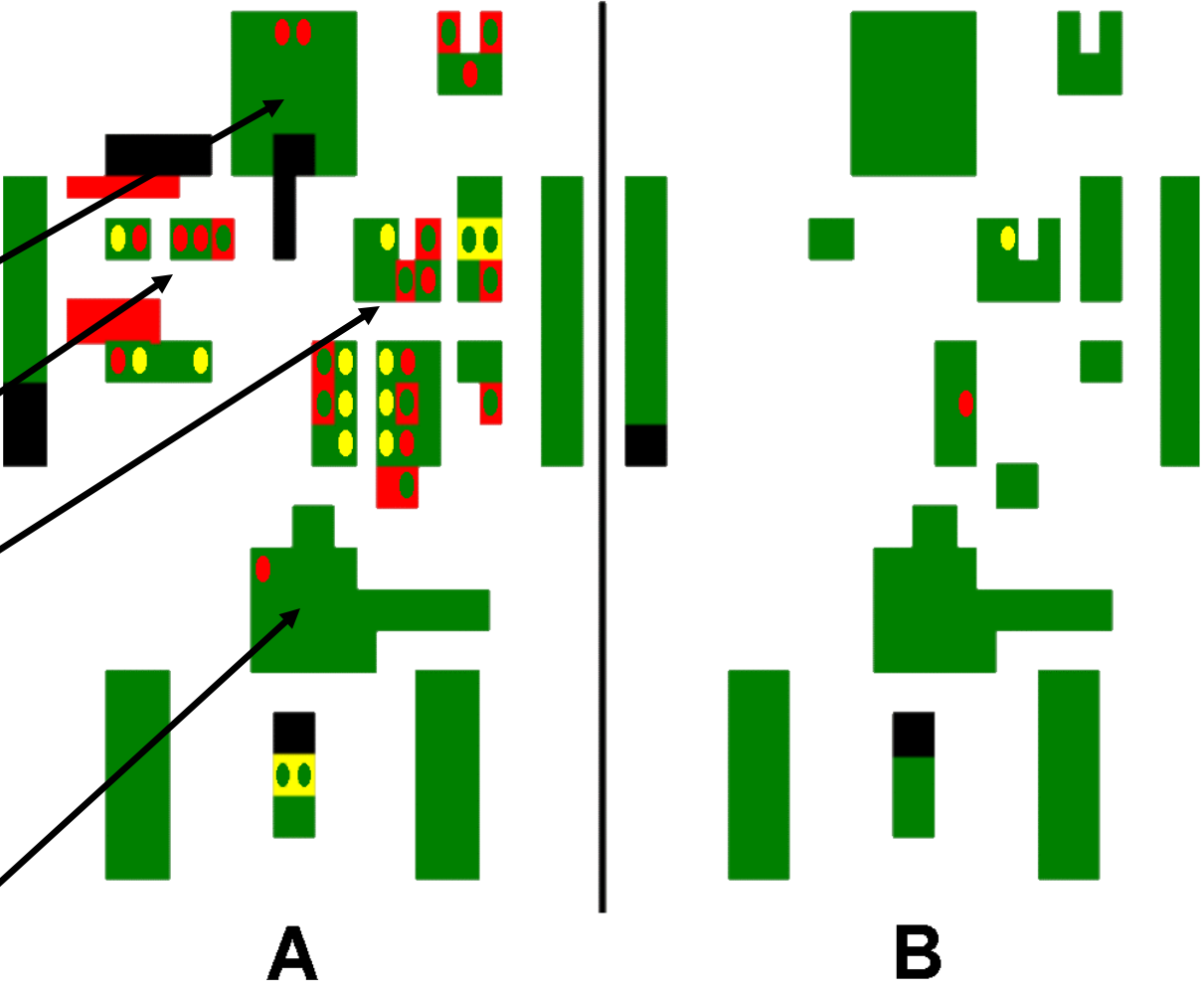


Neurologic

Respiratory

Cardiac

Gastrointestinal

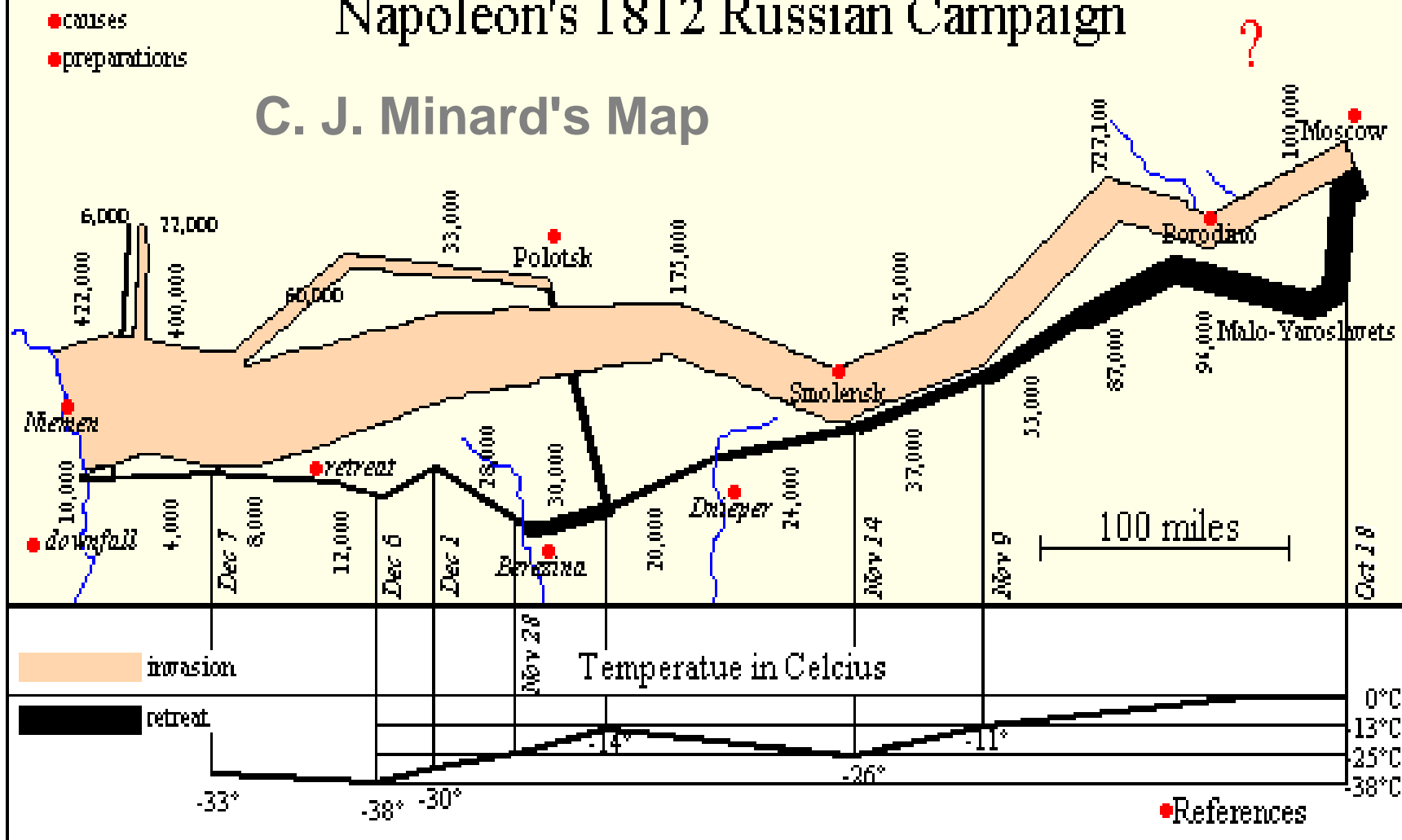


KEGS®

GIFIC©, Patented by Michael Lesser, M.D.

# Napoleon's 1812 Russian Campaign

## C. J. Minard's Map



This flow map is famous for the amount of information it conveys in such a limited space. It plots several variables.

1. the size of the French army depicted by the width of the bands;
2. its location on a two-dimensional surface;
3. the direction of the movement of the advance (upper band) and retreat (lower band);
4. the temperature on certain dates during the retreat

# Diagnostic Assistance

Patient information is compared against a knowledge base to assist in determining diagnosis and management.

Enter findings separated by "," or ";":

CK elevated; AST elevated  
Macrocytic anemia; Depression;  
Paresthesia; No alcohol ingestion  
Weight gain;

Current DXplain Disease List

**COMMON Diseases:**

**Evidence for Dx** **Dx Description** **References**

+ Hypothyroidism, adult  
Alcoholism  
Celiac disease, adult  
Seasonal affective disorder  
Anemia, vitamin B12 deficiency  
Anemia, pernicious

**CELIAC DISEASE, ADULT**

**DIAGNOSTICALLY HELPFUL**

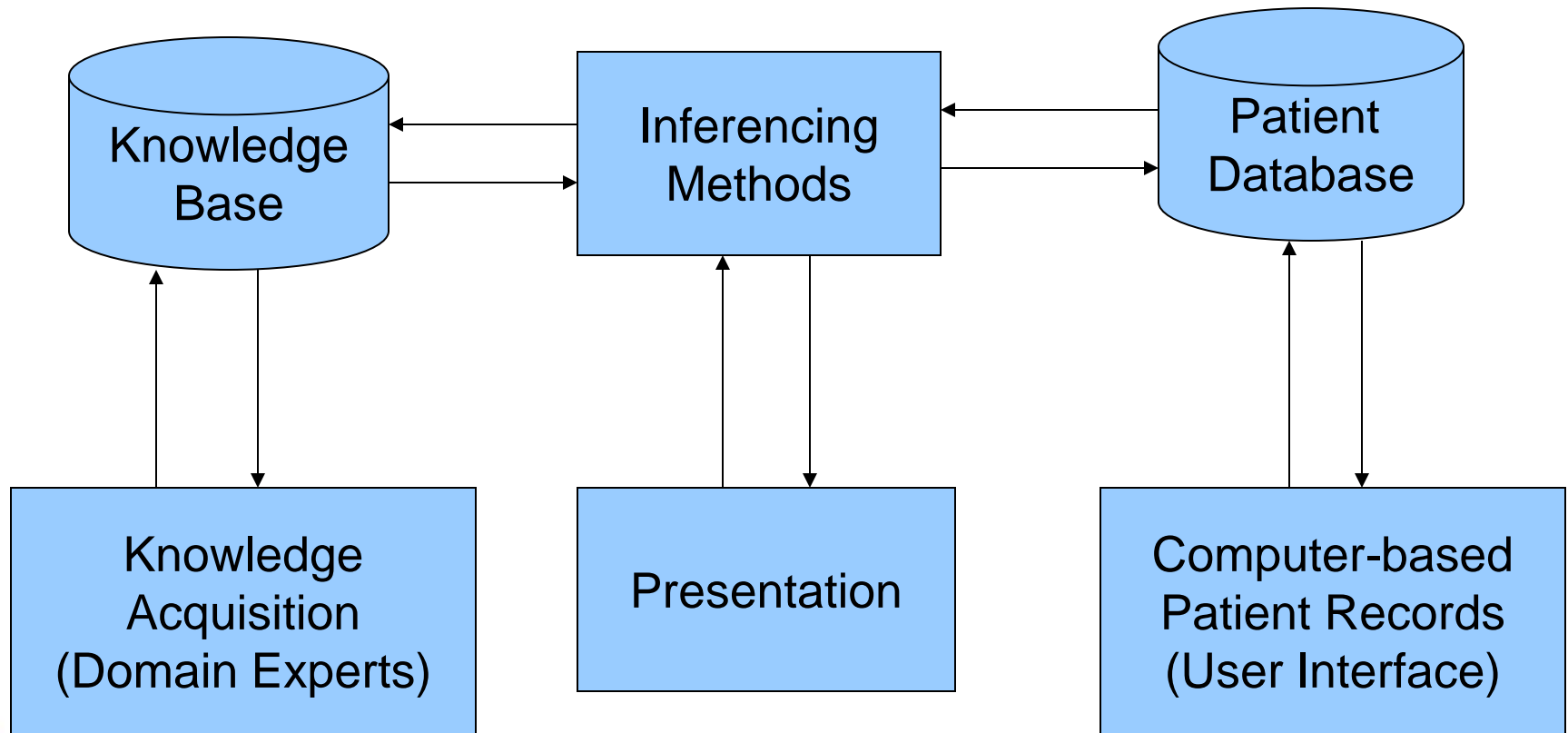
**ALWAYS CONSIDER DIAGNOSIS:** endomysial antibody positive  
**VERY STRONGLY SUPPORTS:** gluten intolerance.  
**STRONGLY SUPPORTS:** diarrhea, chronic; diarrhea, intermittent; weight loss; weight gain; shortness of breath; steatorrhea; stool, foul smelling; stool, frothy; muscle weakness

**REFERENCES**

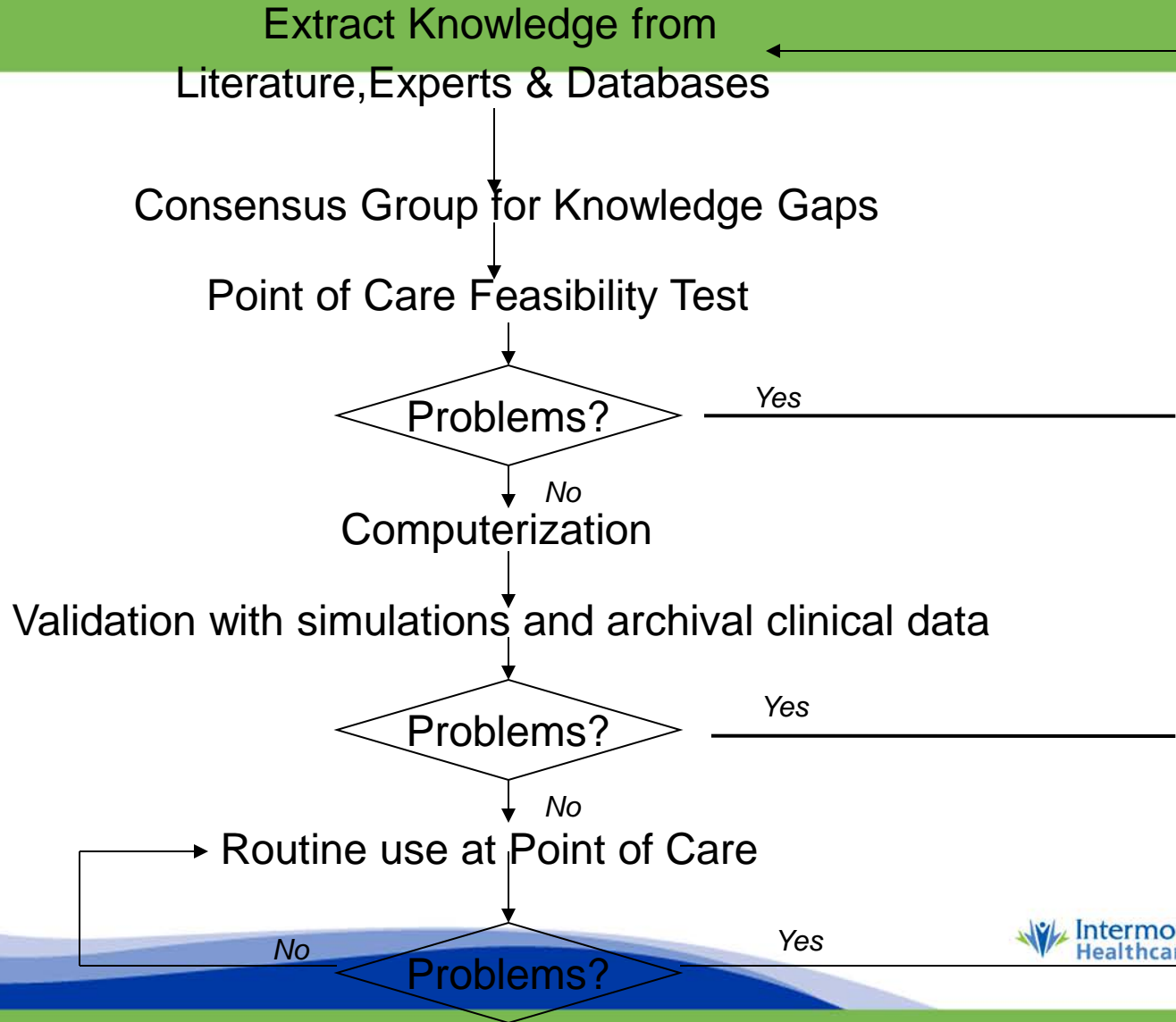
1. Celiac sprue. N Engl J Med 2002 Jan 17;346(3):180-8.

# Developing and Implementing Computerized Decision Support Systems

# Computerized Decision Support Logical Design



# Development and Evaluation





# Developing a CDSS

- Must have a problem to solve
- The problem must be understood
- A reasonable solution exists
- First ingredients:
  - Problem-solving skills
  - Pertinent knowledge
  - Accurate data

# Example Problem – Glucose Management

HELP2 Clinical Desktop (Version 2.15.5) - Microsoft Internet Explorer provided by IHC

HELP2 clinical desktop XTEST, ORME Room: N908 Age: 53Y Sex: M MMI: 547547384 MRN: Options Logout

Protocols - Glucose - Low Range

Select Patient  
Lab  
Micro  
Clinical Notes  
Radiology  
Allergies  
Medications  
Problems  
Vital Signs  
Height/Weight  
Demographics  
ECG  
Insurance  
Message Log  
Lab Order Entry  
Inpatient Reports  
Alert Review  
Web Forms  
HELP/Tandem  
Orders  
Report Manager  
HotText  
Protocols  
Population View  
Encounters  
DRT  
Web Kids  
CAP Protocol

E-Resources  
Online Tutorials  
Password  
CD Info

Comments

Protocols Management  
Glucose - Low Range

**Chart**

Time remaining to next glucose:  
(click for popup timer) **0:00**

Click 'Chart' to record glucose and get instructions.

Accept Reject Review

Date	Time	Prev Drip	Glucose	Calories	Bolus	Drip	D50W	Accepted
No values have been charted for this patient in the last 12 hours.								

Show More

JODE A. Results Review Only LDS Hospital Timeout Status: ● Tue Sep 07, 2004 16:15

Patient data is captured here and run against production rules

Chart Glucose -- Web Page Dialog

Glucose Value:  mg/dl

Glucometer number:

Draw Time: 16:26

Is patient receiving glucose calories?  yes  
(TPN, tube feed, IV dextrose)  no

Enter current insulin rate:  units/hr

Get Instructions Cancel

# Example Problem – Glucose Management

HELP2 Clinical Desktop (Version 2.15.5) - Microsoft Internet Explorer provided by IHC

908 Age: 53Y Sex: M MMI: 547547384 MRN: Options

Select Patient  
Lab  
Micro  
Clinical Notes  
Radiology  
Allergies  
Medications  
Problems  
Vital Signs  
Height/Weight  
Demographics  
ECG  
Insurance  
Message Log  
Lab Order Entry  
Inpatient Reports  
Alert Review  
Web Forms  
HELP/Tandem  
Orders  
Report Manager  
HotText  
Protocols  
Population View  
Encounters  
DRT  
Web Kids  
CAP Protocol

E-Resources  
Online Tutorials  
Password  
CD Info

Comments

Time remaining to next glucose:  
(click for popup timer) **2:00**

Instruction was accepted at 16:31

**Give insulin bolus of 5.0 units.**  
**Set insulin drip to 1.7 units/hour.**

Accept Reject Review

Date	Time	Prev Drip	Glucose	Calories	Bolus	Drip	D50W	Accepted
09/07/2004	16:29	0	200	No	5	1.7		Yes

Show More

XTEST, ORME GLUCOSI  
Glucose - Low Range

**1:59**

Reenter Protocol

JODE A. Results Review Only LDS Hospital Timeout Status: ● Tue Sep 07, 2004 16:32

Instructions are given which the clinician may follow or reject

A specialized timer assists the clinician's workflow

1:59

# Developing a CDSS

- Elicit the knowledge
- Model the knowledge
  - How the data and knowledge relate.
- Acquire and Validate patient data
  - Capture the data
  - Model the data
    - Capture the data in a computable form (i.e., standard terminologies like SNOMED, LOINC, etc.
    - Standardized Terminology *essential!*

# Developing a CDSS

- Choose the appropriate type and level of CDSS for the problem
- DSS Tools – availability and usability
  - Represent the reasoning – turning “clinical judgment” into 1’s and 0’s
- Validate the system’s performance – how does it compare to the “gold standard”?
  - What is the gold standard?
- Integrate the tool.
  - Technical integration – all component systems working together.
  - Human integration – the tool must fit the user.

# Challenges – look familiar?

- Acquiring the data
- Modeling the knowledge
- Eliciting the knowledge
- Representing the reasoning
- Validating performance
- Integrating the tool

# Challenges – Training

- For success, training must be adequate to ensure users:
  - Know enough to run system
  - Value system
  - Trust system
- Changes may require new training

# Challenges – Maintenance

- Determine early how the knowledgebase will be maintained and updated
- Knowledge base must be updated as clinical expertise, protocols and policies change and grow
- Patient care data base must be updated when needed to accommodate new or changes to data elements
- Changes require re-testing of entire system



# Essential to Success

- Clinical Ownership
  - Involvement in idea conception
  - Workflow and requirement definition
  - Design
  - Testing
  - Refinements
  - Updates

# Essential to Success

- Organizational governance and oversight
  - Safety
  - Prioritization

# Questions?

Thank you!