Clinical Decision Support Systems

The Future of Medicine
and
Why It Will Change Your Practice Forever

Stephen J. Ruffenach, DO, MS
Clinical Assistant Professor of Medicine
The University of Arizona
Clinical Decision Support (CDS) Defined

- Clinical Decision Support (CDS) is a process designed to aid directly in clinical decision making, in which characteristics of individual patients are used to generate patient specific interventions, assessments, recommendations, or other forms of guidance that are then presented to a decision making recipient or recipients that can include clinicians, patients, and others involved in care delivery.
  - http://www.healthit.gov
Man

CDSS

Machines

Medicine
Technology Is In Every Field
We are the Patient
We are the Practitioner

Technology will change everything.

What the act of diagnosis and treatment is.

What a patient is.

What a doctor is.
Man

We’ve grown
In numbers

Not so much in size

<table>
<thead>
<tr>
<th>Who</th>
<th>Homo Heidelbergensis</th>
<th>Neanderthal</th>
<th>Homo sapien</th>
<th>Modern man</th>
</tr>
</thead>
<tbody>
<tr>
<td>When</td>
<td>500,000 yrs ago</td>
<td>100,000 yrs ago</td>
<td>1000 yrs ago</td>
<td>Now</td>
</tr>
<tr>
<td>How many</td>
<td>&lt;1 million</td>
<td>1 million</td>
<td>50 million</td>
<td>6.5 billion</td>
</tr>
<tr>
<td>Height (inches)</td>
<td>69</td>
<td>65</td>
<td>68</td>
<td>69</td>
</tr>
</tbody>
</table>
Man
In Many Ways, Hasn’t Changed at All

Lao Tzu (600 BC)
“Health is the greatest possession. Contentment is the greatest treasure. Confidence is the greatest friend.”

“If you are depressed, you are living in the past, if you are anxious, you are living in the future, if you are at peace, you are living in the present.”

Aristotle (600 BC)
“Happiness depends on ourselves.”
The Ancients depended on the gods. The Greeks (500 BC) used science and invoked the gods. That balance still exists.

*Staff of Hermes often confused with that of Aesculapius*
## Medicine

<table>
<thead>
<tr>
<th>Time</th>
<th>Name</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 BC</td>
<td>Aristotle</td>
<td>Observation and Reason</td>
</tr>
<tr>
<td>200 AD</td>
<td>Galen</td>
<td>Surgery</td>
</tr>
<tr>
<td>200 AD</td>
<td>Han Dynasty</td>
<td>Accupuncture</td>
</tr>
<tr>
<td>1200 AD</td>
<td>Europeans</td>
<td>Medical Schools</td>
</tr>
<tr>
<td>1543 AD</td>
<td>Andreas Vesalius</td>
<td>Anatomy and Physiology</td>
</tr>
<tr>
<td>1850 AD</td>
<td>Louis Pasteur</td>
<td>Germ Theory</td>
</tr>
<tr>
<td>1903s</td>
<td>W. Einthoven</td>
<td>EKG</td>
</tr>
<tr>
<td>1950s</td>
<td>Alexander Fleming</td>
<td>Antibiotics</td>
</tr>
<tr>
<td>1990s</td>
<td>Modern Society</td>
<td>Genome</td>
</tr>
</tbody>
</table>
Machines

Technology advances continuously

Machines are a by-product of that advancement

Modern medicine advances with technology and machines

Moore’s Law clarifies the rate of the advancement
Man

CDSS

Machines

Medicine
Decision Making Circa 1997

Decision Making in the New World

Man

Medicine

CDSS

Technical

Methodical

Machines

Interpersonal
Why CDSS will Come to Pass

Clinical Demand
Computational Abilities
Consumer Expectations
Clinical Demand

Figure 1: Number of Persons 65+, 1900 - 2030 (numbers in millions)
Clinical Demand

Projected Supply and Demand, Physicians, 2008-2020
(ALL SPECIALTIES)

Association of American Medical Colleges
Computational Abilities

Moore’s Law
states that available computational power doubles every 18-24 months.

Metcalf’s Law
states that the value of a telecommunications network is proportional to the square of the number of connected users of the system.
Consumer Expectations

- Patients want their healthcare questions answered:
  - Quickly
  - Compassionately
  - Personalized

- Want their evidence at the individual-patient level
Consumer Expectations

“Where do you find information to make decisions about healthcare?”

The Internet & Doctors Rank Highest; Friends, Family and Media Follow

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grocery stores/supermarkets</td>
<td>7%</td>
</tr>
<tr>
<td>Schools</td>
<td>7%</td>
</tr>
<tr>
<td>Health clubs</td>
<td>8%</td>
</tr>
<tr>
<td>Community services</td>
<td>14%</td>
</tr>
<tr>
<td>Social networking websites</td>
<td>17%</td>
</tr>
<tr>
<td>Government</td>
<td>21%</td>
</tr>
<tr>
<td>The hospital</td>
<td>22%</td>
</tr>
<tr>
<td>TV or radio</td>
<td>24%</td>
</tr>
<tr>
<td>Magazine or newspapers</td>
<td>27%</td>
</tr>
<tr>
<td>Friends or family</td>
<td>30%</td>
</tr>
<tr>
<td>Doctors</td>
<td>43%</td>
</tr>
<tr>
<td>Health website</td>
<td>48%</td>
</tr>
</tbody>
</table>

PricewaterhouseCoopers, 2010
Why We Will Embrace CDSS (and perhaps why we shouldn’t)

- Cost
- Convenience
- Confidence

One Billion Smart Phones By 2016!
Why We Need CDSS

- Physicians don’t always do the right thing
- Important clinical procedures often not done

<table>
<thead>
<tr>
<th>Clinical Procedure</th>
<th>Landmark Trial</th>
<th>National Use Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flu vaccination</td>
<td>1968</td>
<td>55%</td>
</tr>
<tr>
<td>Pneumococcal Vac.</td>
<td>1977</td>
<td>36%</td>
</tr>
<tr>
<td>Beta Blocker After MI</td>
<td>1982</td>
<td>62%</td>
</tr>
<tr>
<td>Mammography</td>
<td>1982</td>
<td>62%</td>
</tr>
<tr>
<td>FOBT</td>
<td>1986</td>
<td>17%</td>
</tr>
<tr>
<td>Diabetic Foot Care</td>
<td>1993</td>
<td>20%</td>
</tr>
</tbody>
</table>

How Do CDS Systems Work?

- There are three parts to most CDSS
  - The knowledge base
    - compiled information that is often, but not always, in the form of if-then rules.
    - contains information about diseases and their signs and symptoms.
  - The inference or reasoning engine
    - contains the formulas for combining the rules in the knowledge base with actual patient data.
    - maps the patient signs and symptoms to those diseases and might suggest some diagnoses for the clinicians to consider.
  - The mechanism to communicate with the user

How Do CDS Systems Work

Data Input -> Inference Engine -> Knowledge Base

- Combines knowledge base rules with clinical data
- Suggests dx and tx plan

Knowledge Base:
- If then rules
- Disease Information

Results Output
How Do CDS Systems Think?

• Deterministic
  – Linear Rule-Based Systems
  – First-order rules applied

• Probabilistic
  – Non-Linear, distributed, parallel processing
  – Neural Networks
Rule-Based Systems

• **Forward Chain Rules**
  – Start with data, apply rule
  – Use if sparse data

• **Backward Chain Rules**
  – Start with “goal rule” and apply to each required premise
  – Use if lots of data

• **Problems with Rules**
  – Contradictory, circular
  – Countless
  – Conformity problems
Neural Networks

- Computational structure modeled after animal’s CNS
- Processes input non-linearly
  - Assign adaptive weights
  - Learn algorithms
  - Approximates outputs
Neural Networks

Accepts various inputs
The hidden layer recodes the data
Each connection has a weight
Multiple outputs are possible
Five Key CDS Types in Current EMR (Low Hanging Fruit)

• 1. Order Sets
• 2. Alerts
• 3. Referential Content
• 4. Nursing Care Plans
• Drug Database

David C. Rhew, MD
HIMMS, 2011
CDSS is Coming
Stages of Meaningful Use Will Occur Over Five Years

2011-2012
Stage 1
Data Capture And Sharing

2014
Stage 2
Advanced Clinical Processes

2016
Stage 3
Improved Outcomes
Meaningful Use and CDSS

• Stage 1
  – **Objective:** Implement one clinical decision support rule relevant to specialty or high clinical priority along with the ability to track compliance that rule
  – **Measure:** Implement one clinical decision support rule

• Stage 2
  – **Objective:** Use clinical decision support to improve performance on high-priority health conditions
  – **Measure:** Implement 5 clinical decision support interventions related to 4 or more clinical quality measures
Do CDS Systems Indeed Work?

Initial studies were not promising

Reduction in ADEs were the earliest benefits

Workflow and knowledge management problems hounded most systems

Now the tide is changing.
# HIT/CDS Is Being Studied

## Table 1. Health IT Evaluation Studies Between 1995 and 2013, by Study Outcome Type

<table>
<thead>
<tr>
<th>Meaningful Use Functionality</th>
<th>Outcome, n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quality</td>
</tr>
<tr>
<td>Clinical decision support</td>
<td>257</td>
</tr>
<tr>
<td>Computerized provider order entry</td>
<td>63</td>
</tr>
<tr>
<td>Multifunctional health IT intervention</td>
<td>146</td>
</tr>
<tr>
<td>Patient care reminders</td>
<td>48</td>
</tr>
<tr>
<td>e-Prescribing</td>
<td>15</td>
</tr>
<tr>
<td>Patient access to electronic records</td>
<td>17</td>
</tr>
<tr>
<td>Health information exchange</td>
<td>5</td>
</tr>
<tr>
<td>Clinical laboratory test results</td>
<td>4</td>
</tr>
<tr>
<td>Medication lists</td>
<td>1</td>
</tr>
<tr>
<td>Electronic immunization registries</td>
<td>2</td>
</tr>
<tr>
<td>Other meaningful use*</td>
<td>15</td>
</tr>
<tr>
<td>All meaningful use</td>
<td>573</td>
</tr>
</tbody>
</table>

*IT = information technology.*  
*Includes patient-specific education, patient lists by condition, summary of care records, and problem lists.*
Table 2. Health IT Evaluation Studies Between 2007 and 2013, by Study Outcome Result*

<table>
<thead>
<tr>
<th>Meaningful Use Functionality</th>
<th>Outcome Result, %</th>
<th>Total, n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
<td>Mixed</td>
</tr>
<tr>
<td>Clinical decision support</td>
<td>65</td>
<td>17</td>
</tr>
<tr>
<td>Computerized provider order entry</td>
<td>63</td>
<td>16</td>
</tr>
<tr>
<td>Multifunctional health IT</td>
<td>51</td>
<td>33</td>
</tr>
<tr>
<td>intervention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health information exchange</td>
<td>64</td>
<td>30</td>
</tr>
<tr>
<td>Patient lists by condition</td>
<td>73</td>
<td>17</td>
</tr>
<tr>
<td>e-Prescribing</td>
<td>52</td>
<td>28</td>
</tr>
<tr>
<td>Patient access to electronic</td>
<td>60</td>
<td>25</td>
</tr>
<tr>
<td>records</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient care reminders</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>Other meaningful use functionalities†</td>
<td>55</td>
<td>36</td>
</tr>
<tr>
<td>Total meaningful use</td>
<td>60</td>
<td>24</td>
</tr>
</tbody>
</table>

IT = information technology.
* Includes studies from the 2 most recent systematic reviews (Buntin et al [6] and the current review), covering health IT evaluation studies published between July 2007 and August 2013.
† Includes patient-specific education, medication lists, clinical laboratory test results, immunization registries, summary of care records, and problem lists.

What does the future hold?

“The most important question appears not to be "Where can we use computers?" but "Where must we use human beings?"

Marsden S. Blois, MD, FACMI

Clinical Judgment and computers,
Where must we use human beings?

- Mayo Clinic in 2006 identified the most important characteristics patients feel a good doctor must possess.
- The ideal clinician is:
  - Confident
  - Empathetic
  - Humane
  - Personal
  - Forthright
  - Respectful
  - Thorough