Medical Informatics

Stephen J. Ruffenach, DO, MS

Hospitalist, Oro Valley Hospital

Director of Informatics,

EmCare Hospitalist Group

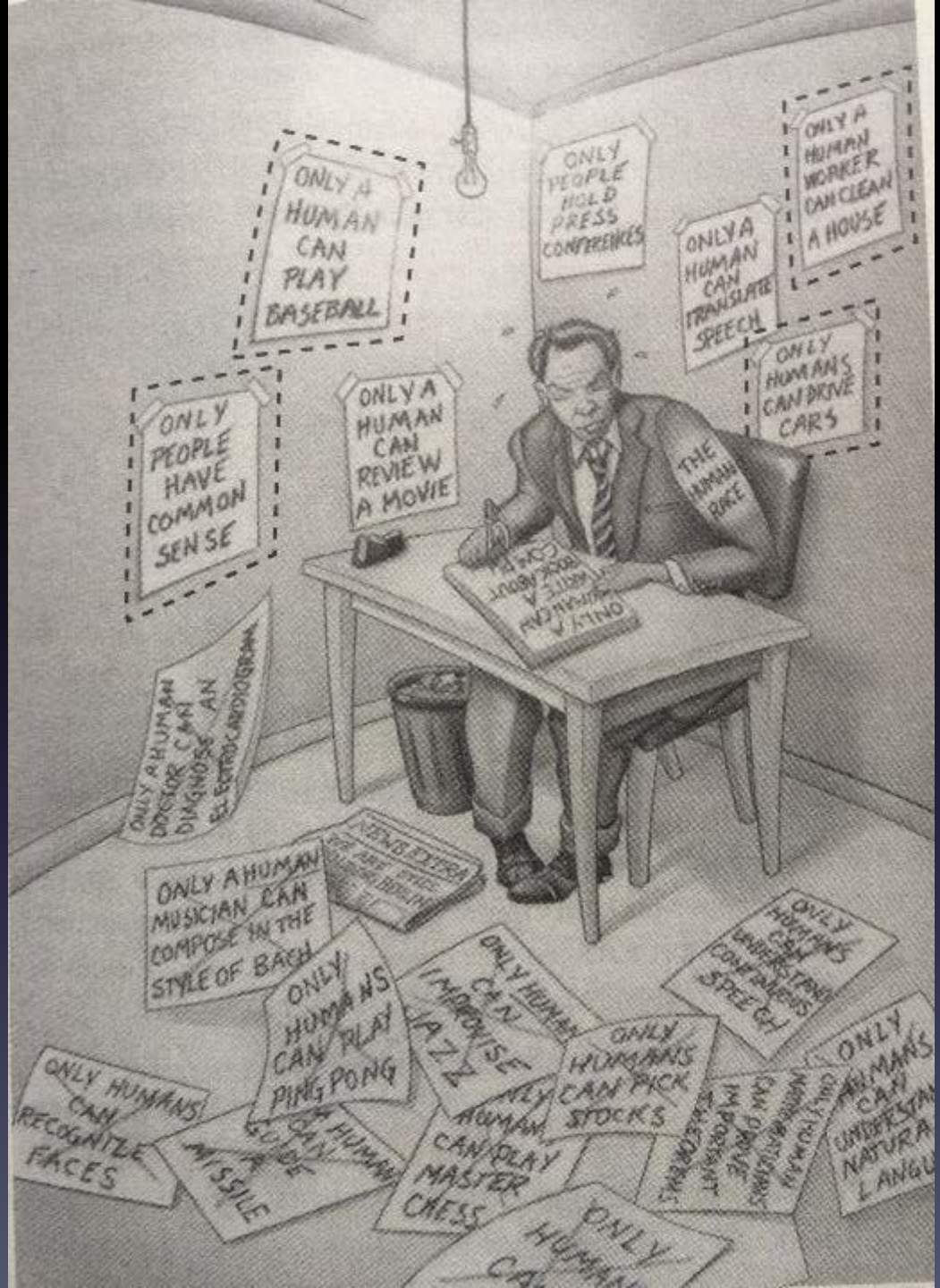
Information and Technology

- *"It will produce forgetfulness in the minds of those who learn to use it "*

Socrates 370 BC

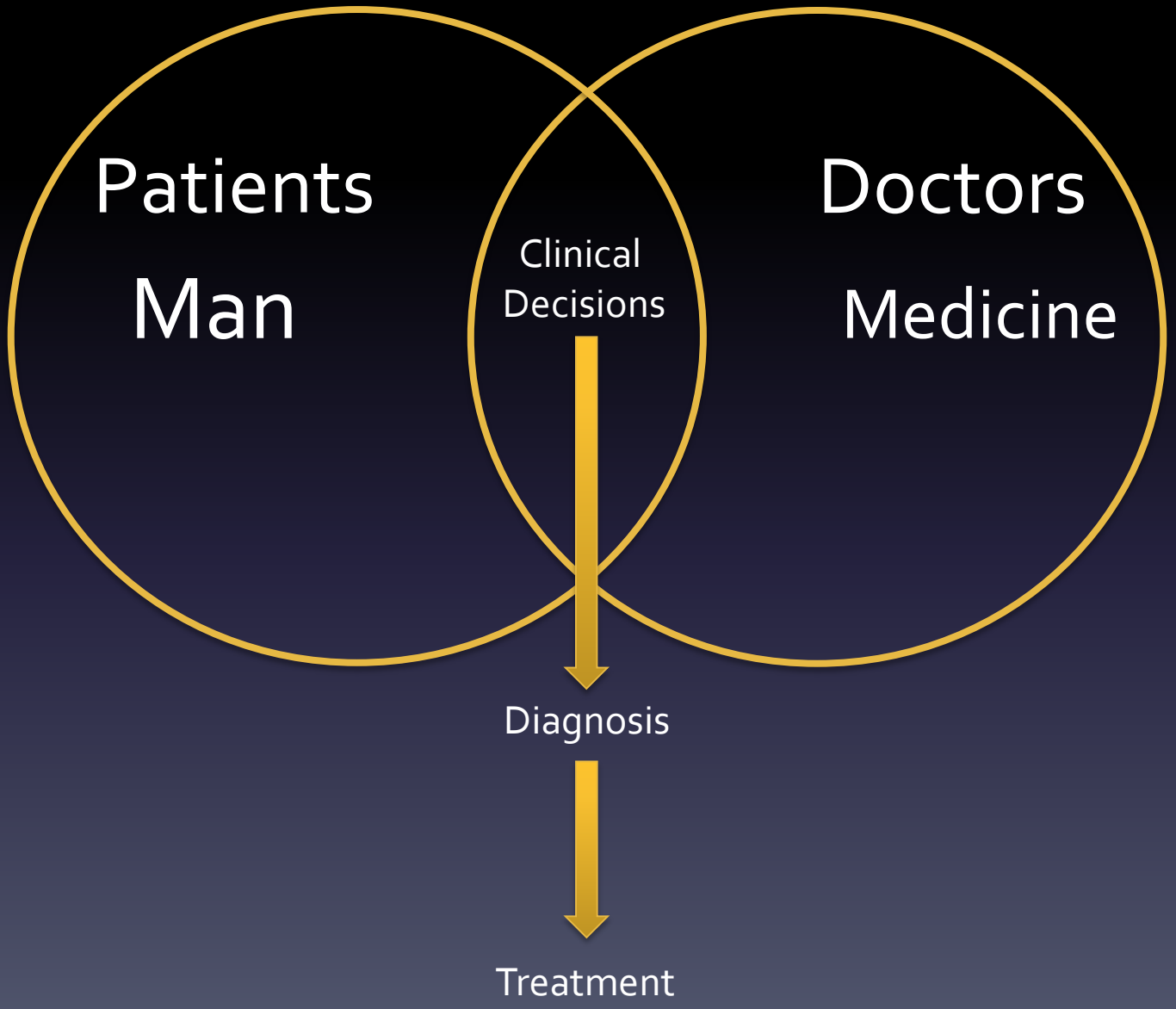
Regarding the invention of writing

Technology will always move forward and always produce positive and negative changes.

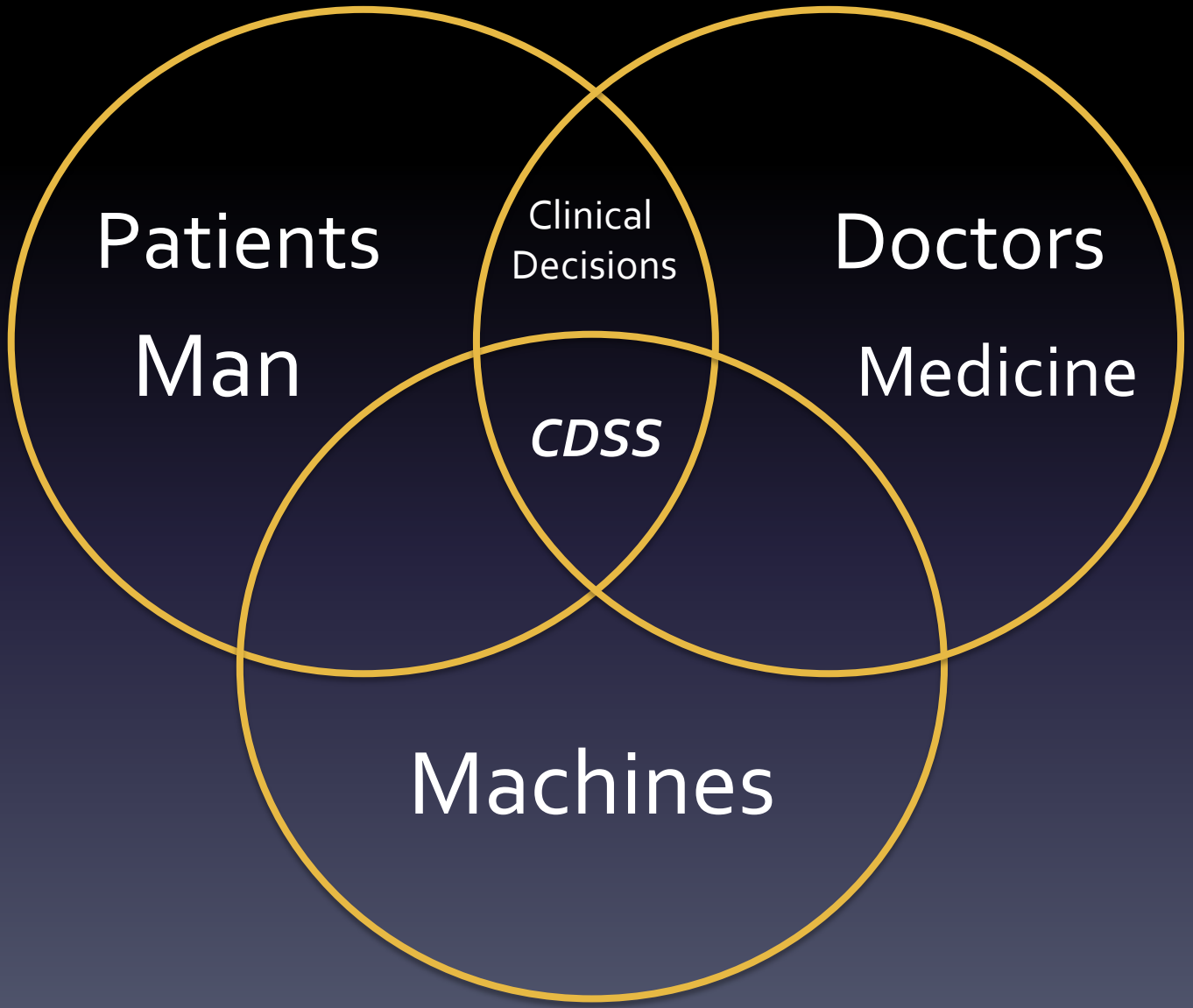

ONLY A HUMAN CAN PLAY BASEBALL
ONLY PEOPLE HOLD PRESS CONFERENCES
ONLY A HUMAN WORKER CAN CLEAN A HOUSE
ONLY A HUMAN CAN TRANSLATE SPEECH
ONLY HUMANS CAN DRIVE CARS
ONLY PEOPLE HAVE COMMON SENSE
ONLY A HUMAN CAN REVIEW A MOVIE
THE HUMAN RACE
ONLY A HUMAN DOCTOR CAN DIAGNOSE AN ELECTROCARDIOGRAM
ONLY A HUMAN MUSICIAN CAN COMPOSE IN THE STYLE OF BACH
ONLY HUMANS CAN PLAY PING PONG
ONLY HUMANS CAN RECOGNIZE FACES
ONLY HUMANS CAN PICK STOCKS
ONLY HUMANS CAN UNDERSTAND CONVERSATIONAL SPEECH
ONLY HUMANS CAN IMPROVISE JAZZ
ONLY A HUMAN CAN PLAY MASTER CHESS

Changes are Coming

Clinical Decisions
Yesterday



Clinical Decisions
Today

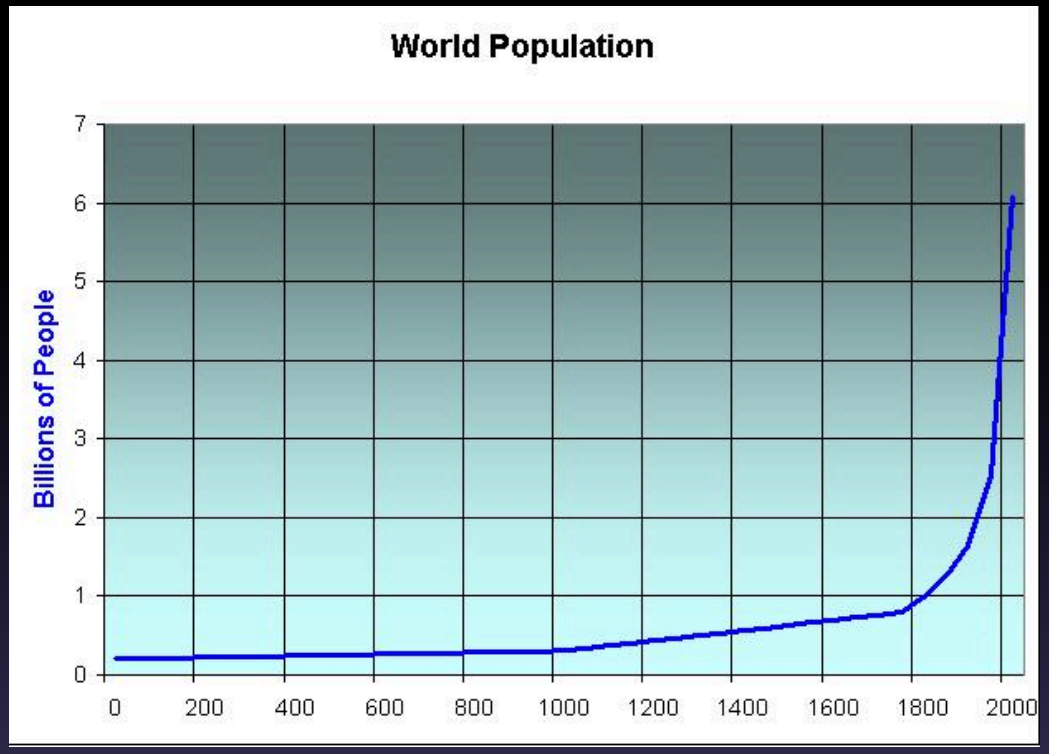


Clinical Decision Support (CDS) Defined

- 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

We've grown
In numbers

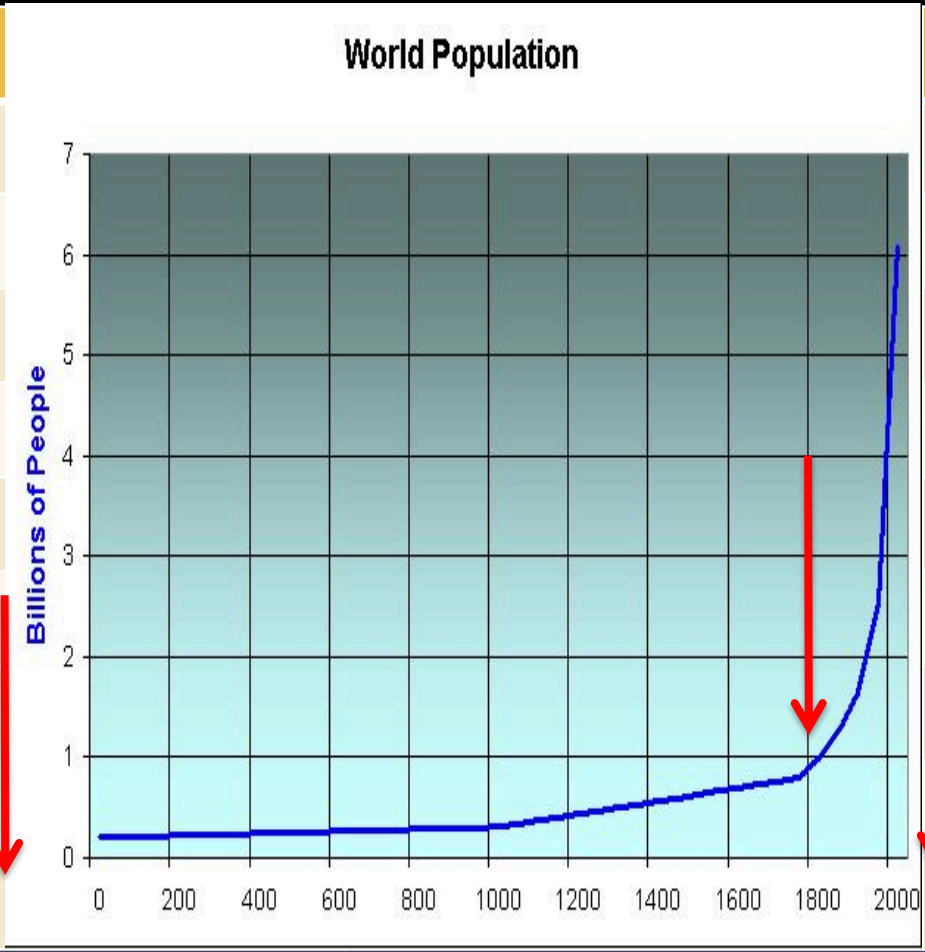


Not so much in size

Who	*Homo Heidelbergensis*	Neanderthal	*Homo sapien*	Modern man
When	500,000 yrs ago	100,000 yrs ago	1000 yrs ago	Now
How many	< 1 million	1 million	50 million	6.5 billion
Height (inches)	69	65	68	69

Medicine

Time	Action
400 BC	Observation and Reason
200 AD	Surgery
200 AD	Accupuncture
1200 AD	Medical Schools
1543AD	Anatomy and Physiology
1850 AD	Germ Theory
1903s	EKG
1950s	Antibiotics
1990s	Genome



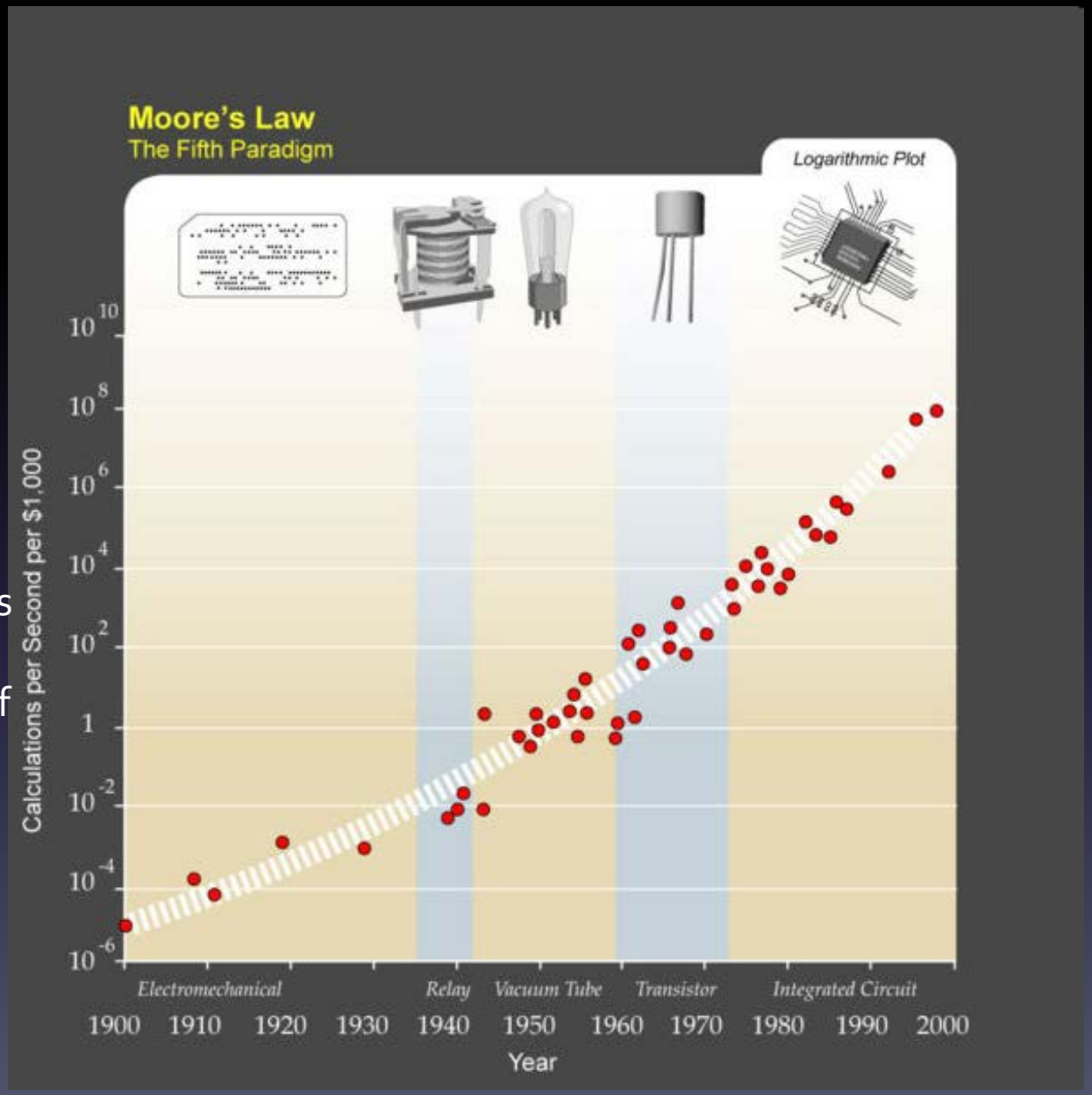
Machines

Technology advances continuously

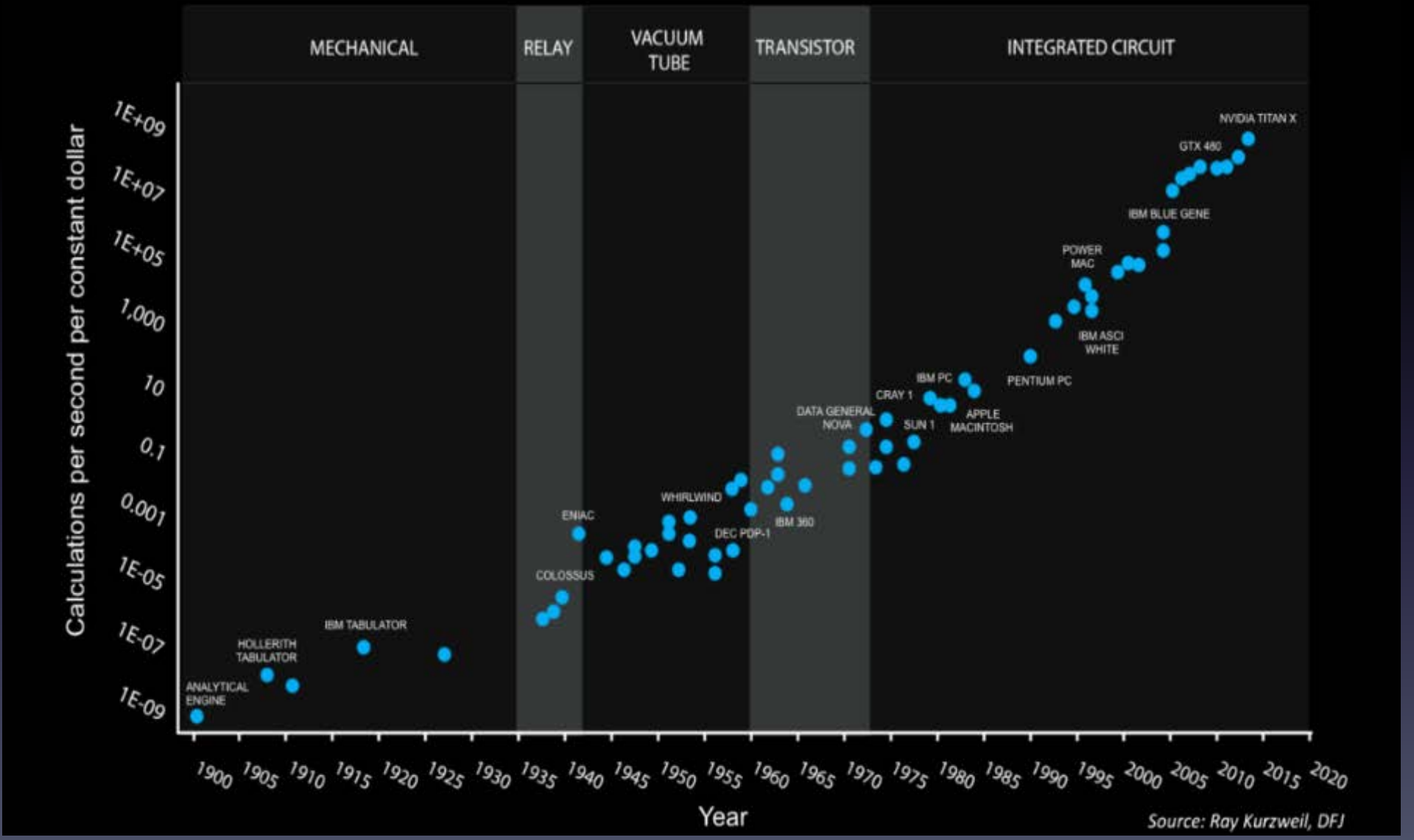
Machines are a by-product of that advancement

Modern medicine advances with technology and machines

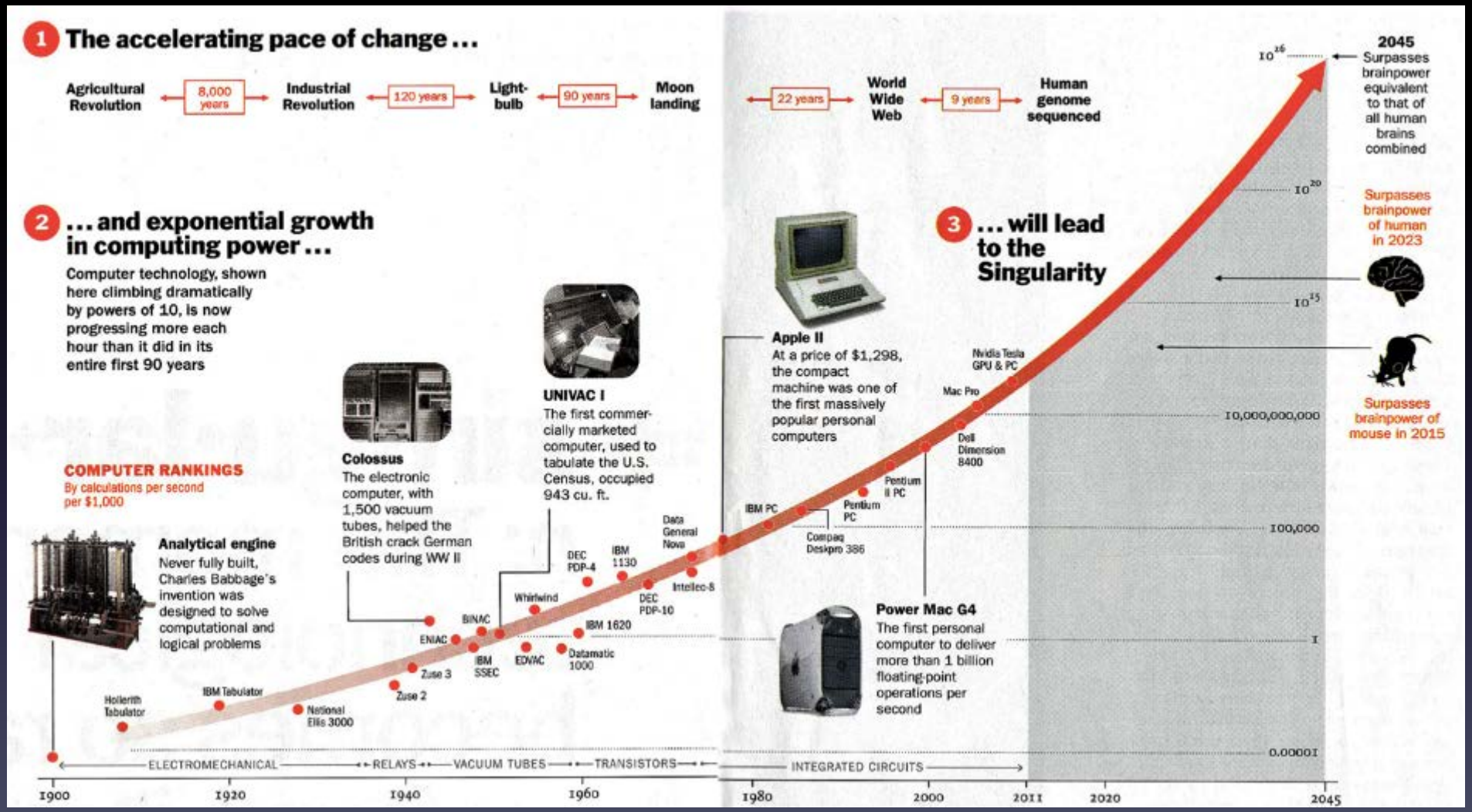
Moore's Law clarifies the rate of the advancement



120 Years of Moore's Law

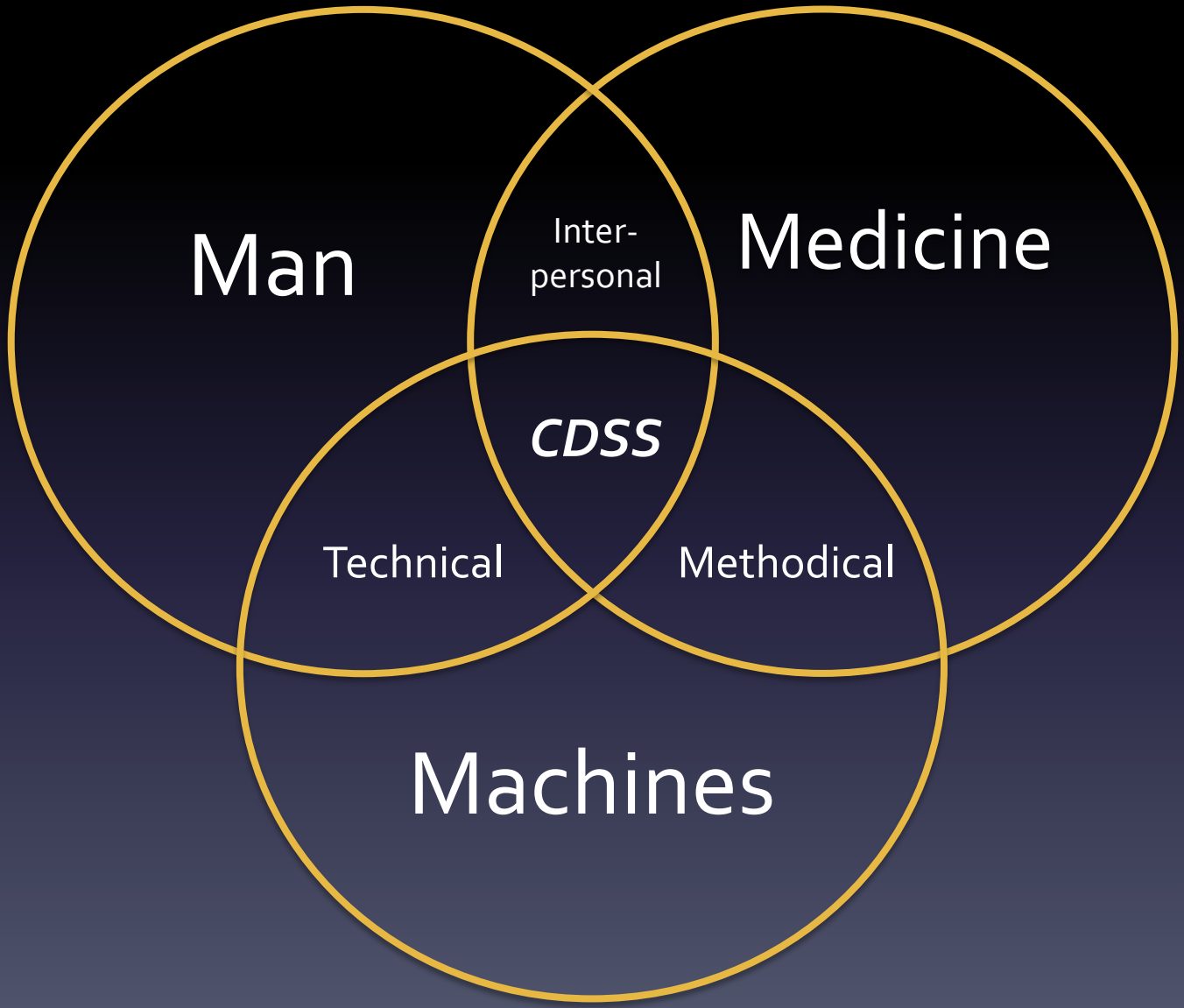


Computational Power and Machines March On



Time Magazine, February 10, 2014

Clinical Decision Making in the New World



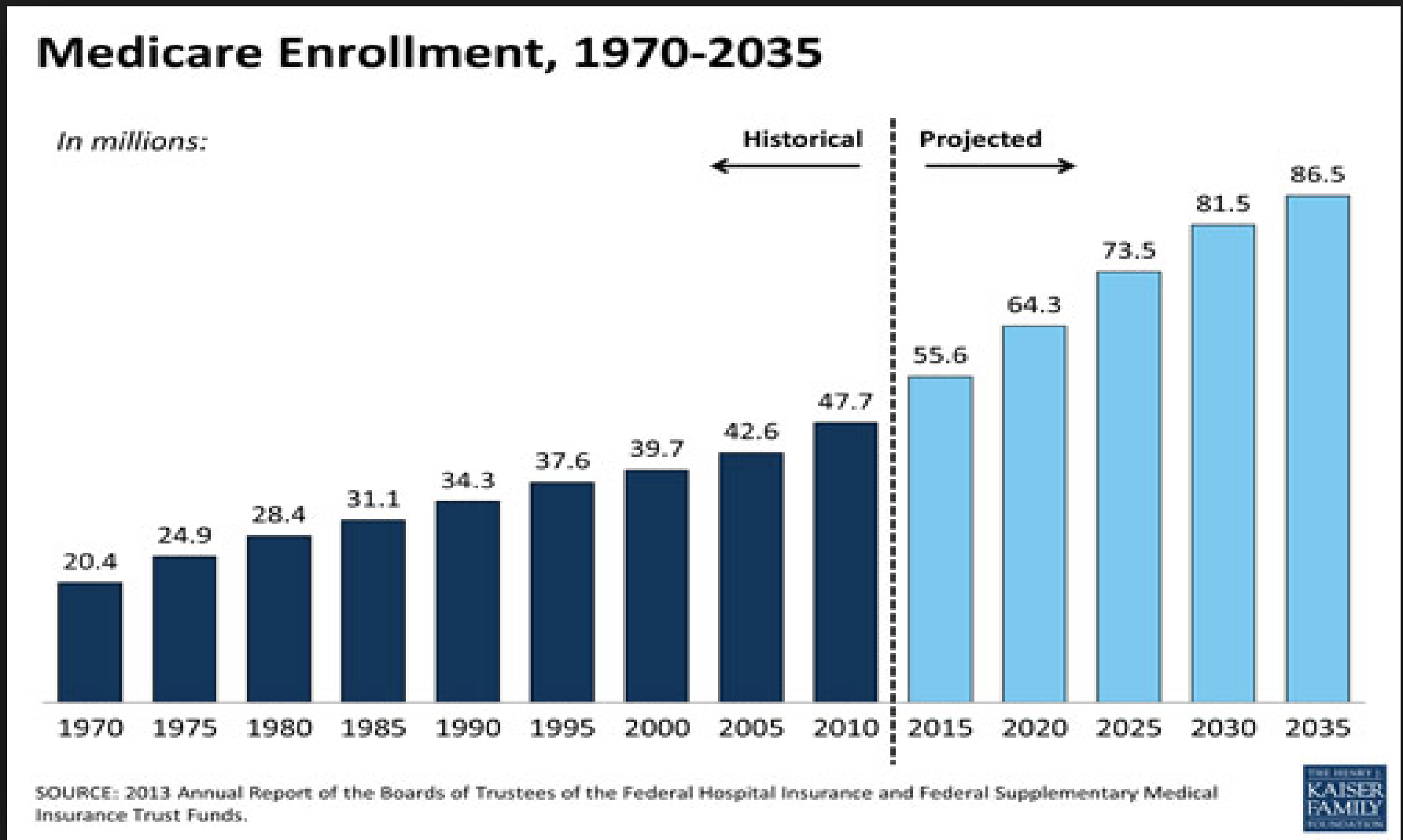
Why CDSS Will Become Increasingly Important

Clinical Demand

Computational Abilities

Consumer Expectations

Clinical Demand



Clinical Demand

- 24% of the US population is > 49 years old
- 17 million are between 75 and 85 years old
  - Will be 30 million by 2045
- Health care costs = 18% of the US GNP
  - 28% spent in last 6 months of life

Lewis, Stephen F
American Journal of Medicine
February 2016
Vol 129, No.2

Clinical Demand

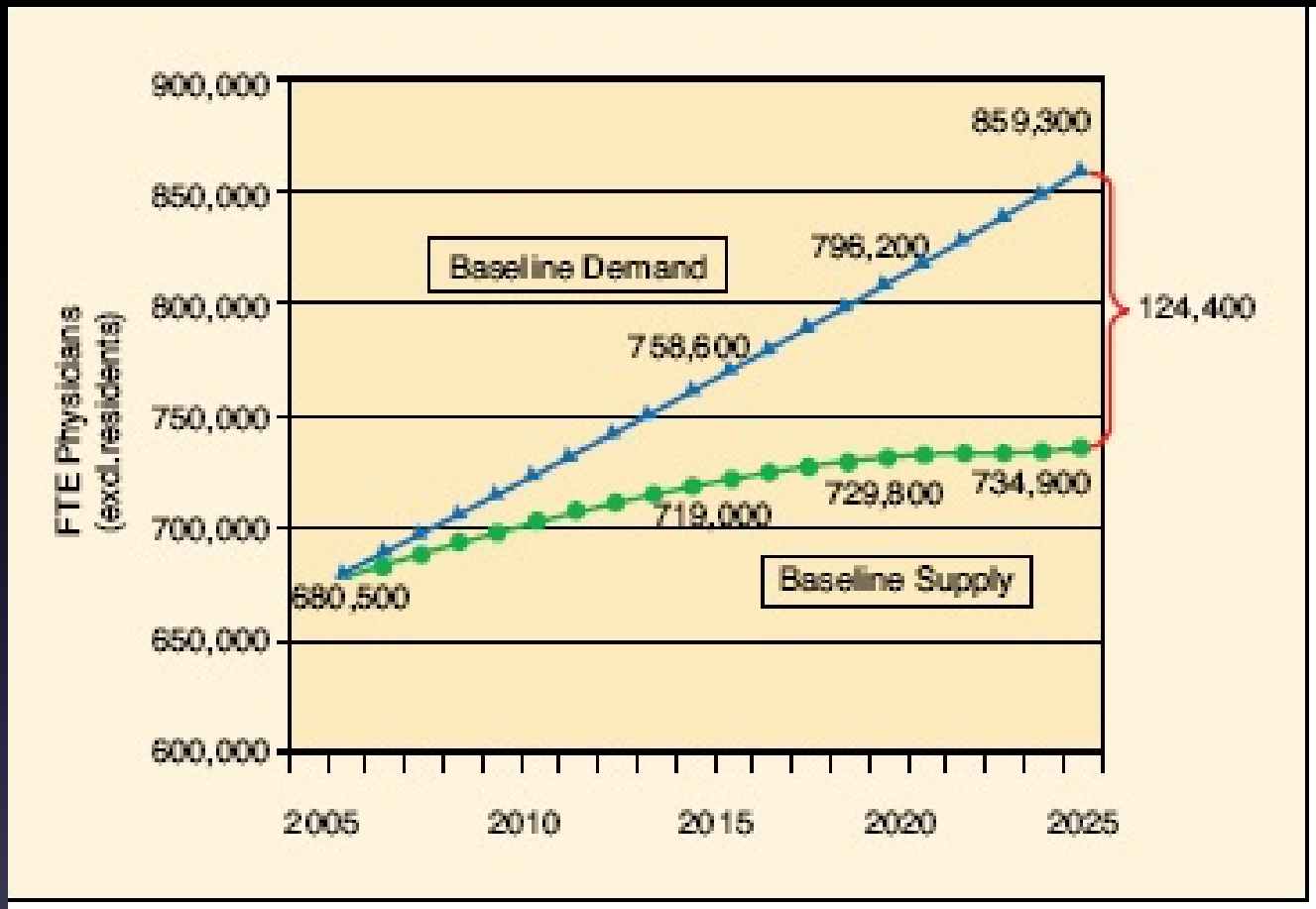
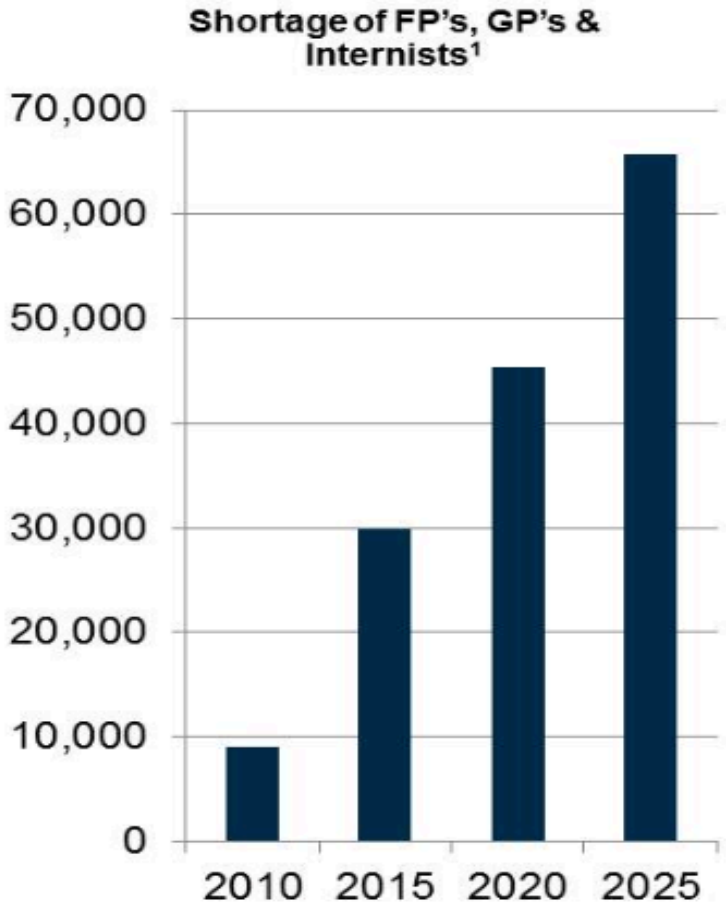


Figure 1. Baseline Physioian Full-Time Employee (FTE) Supply and Demand Projeotions, 2006 – 2025.[2]

JAMA. 2000; 284:2762-2770.

Clinical Demand

SHORTAGE OF PRIMARY CARE PHYSICIANS PROJECTED TO WORSEN

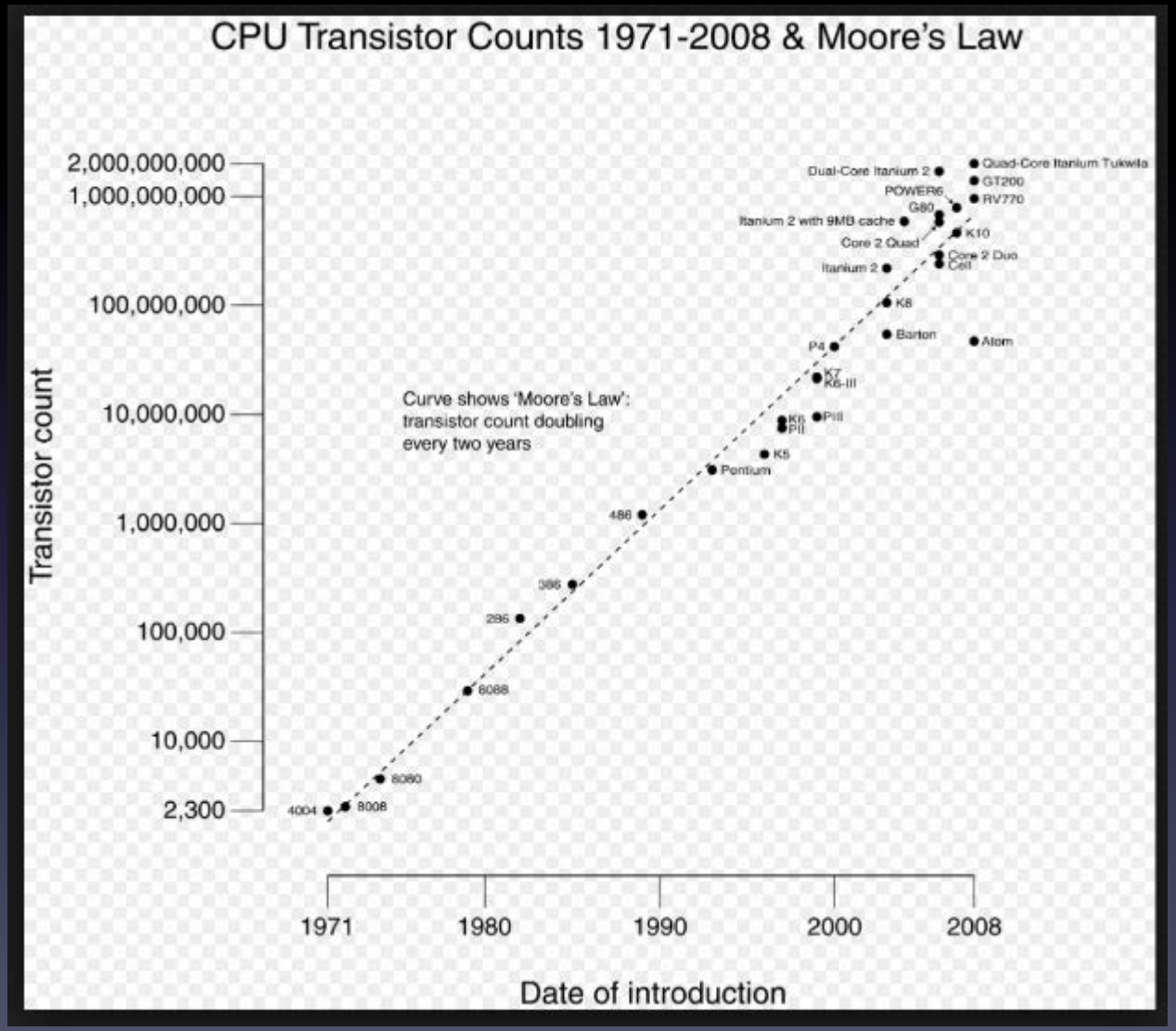


Sources: [1]AAMC. The Impact of health care reform on the future supply and demand for physicians: Updated projections through 2025. June 2010; [2]Filling the Void: Physician Outlook and Practice Trends, 2013. Reported by Jackson Healthcare. http://www.jacksonhealthcare.com/media/191888/2013physiciantrends-void_ebk0513.pdf

Computational Abilities

Moore's Law

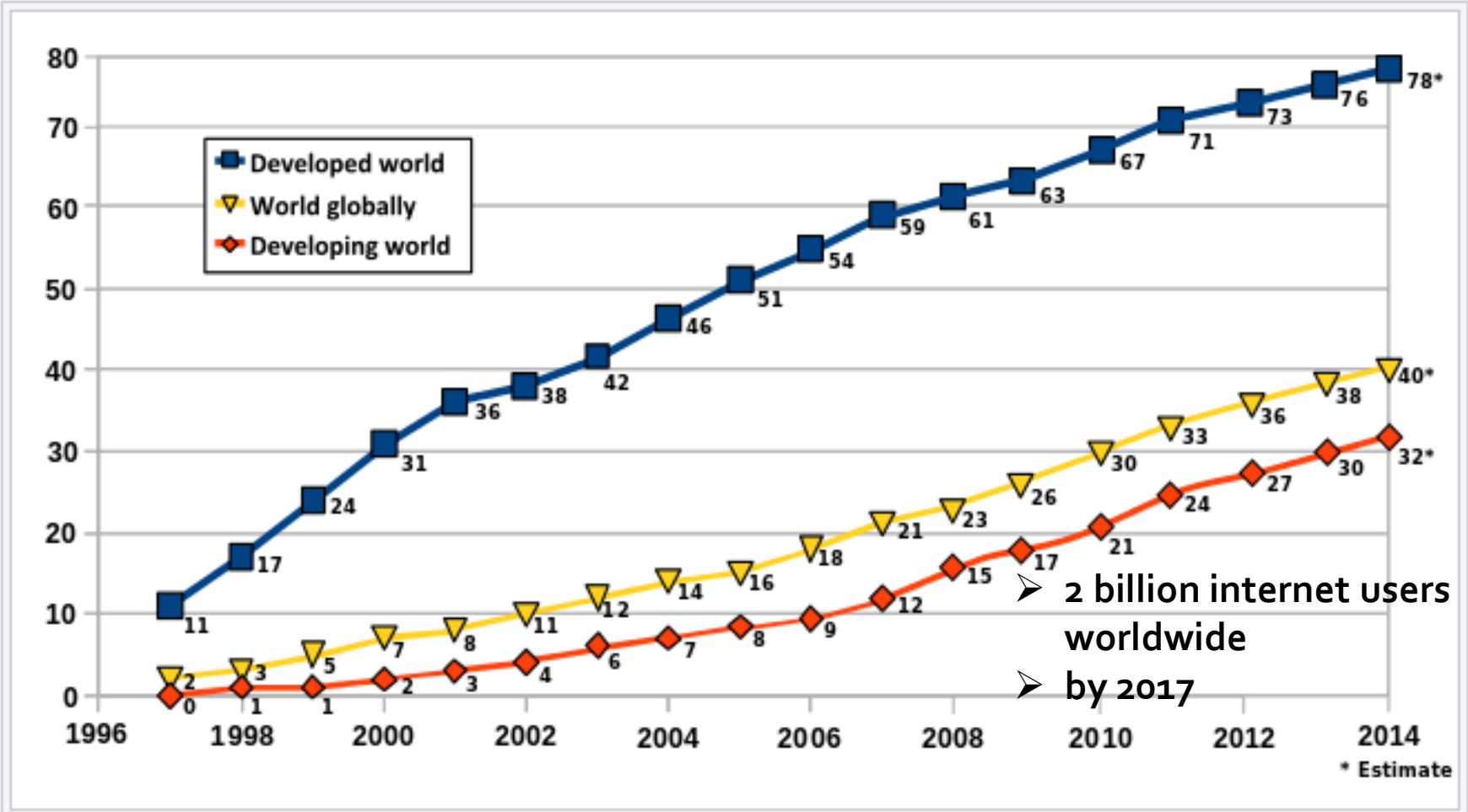
states that available computational power doubles every 18-24 months



Computational Abilities

Internet users [edit]

Main article: List of countries by number of Internet users



- 2 billion internet users worldwide
- by 2017

Internet users per 100 inhabitants

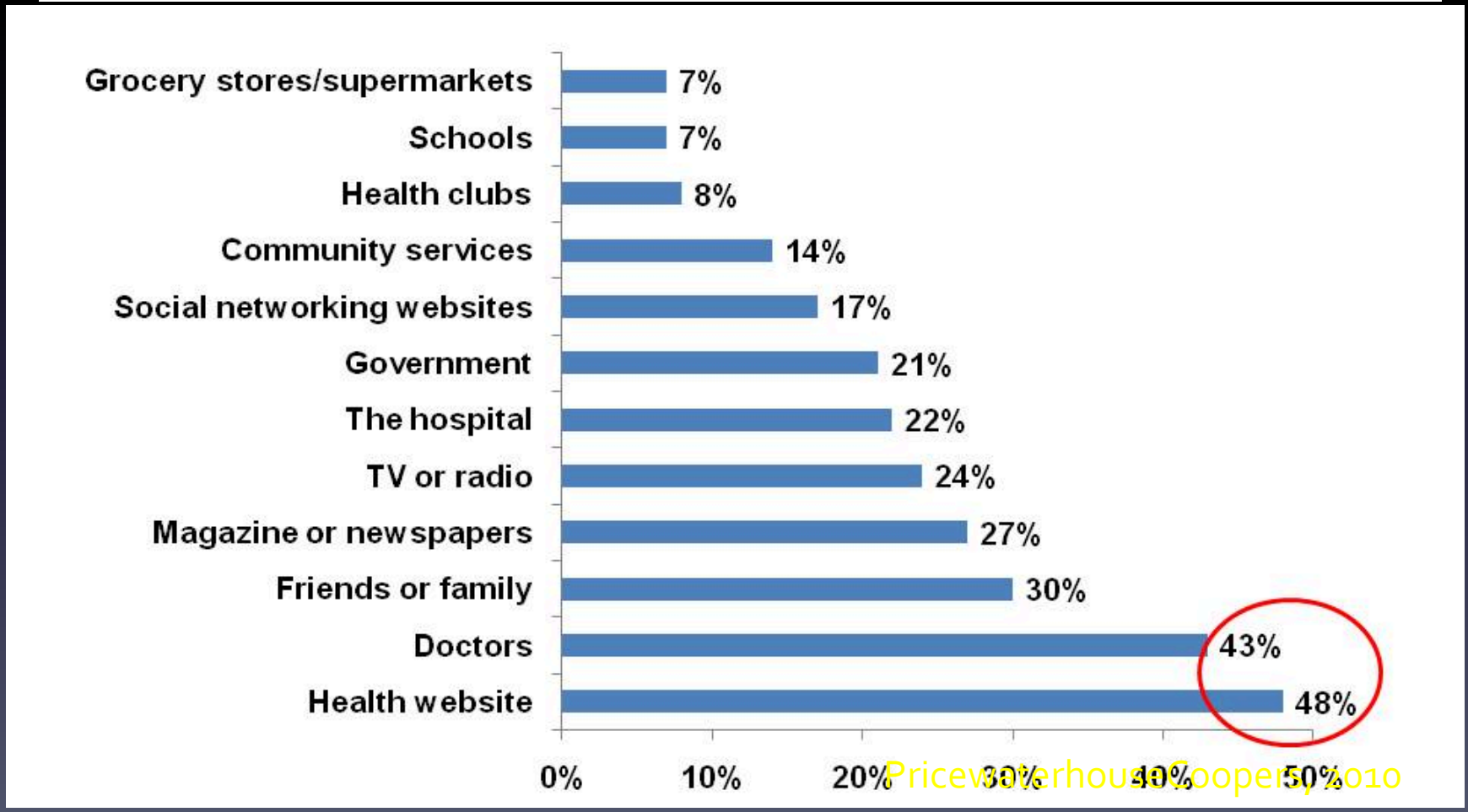
Source: International Telecommunications Union.[1][2]

Consumer Expectations

- Patients want their healthcare questions answered:
  - Quickly
  - Compassionately
  - Personalized
    - Want their evidence at the individual-patient level

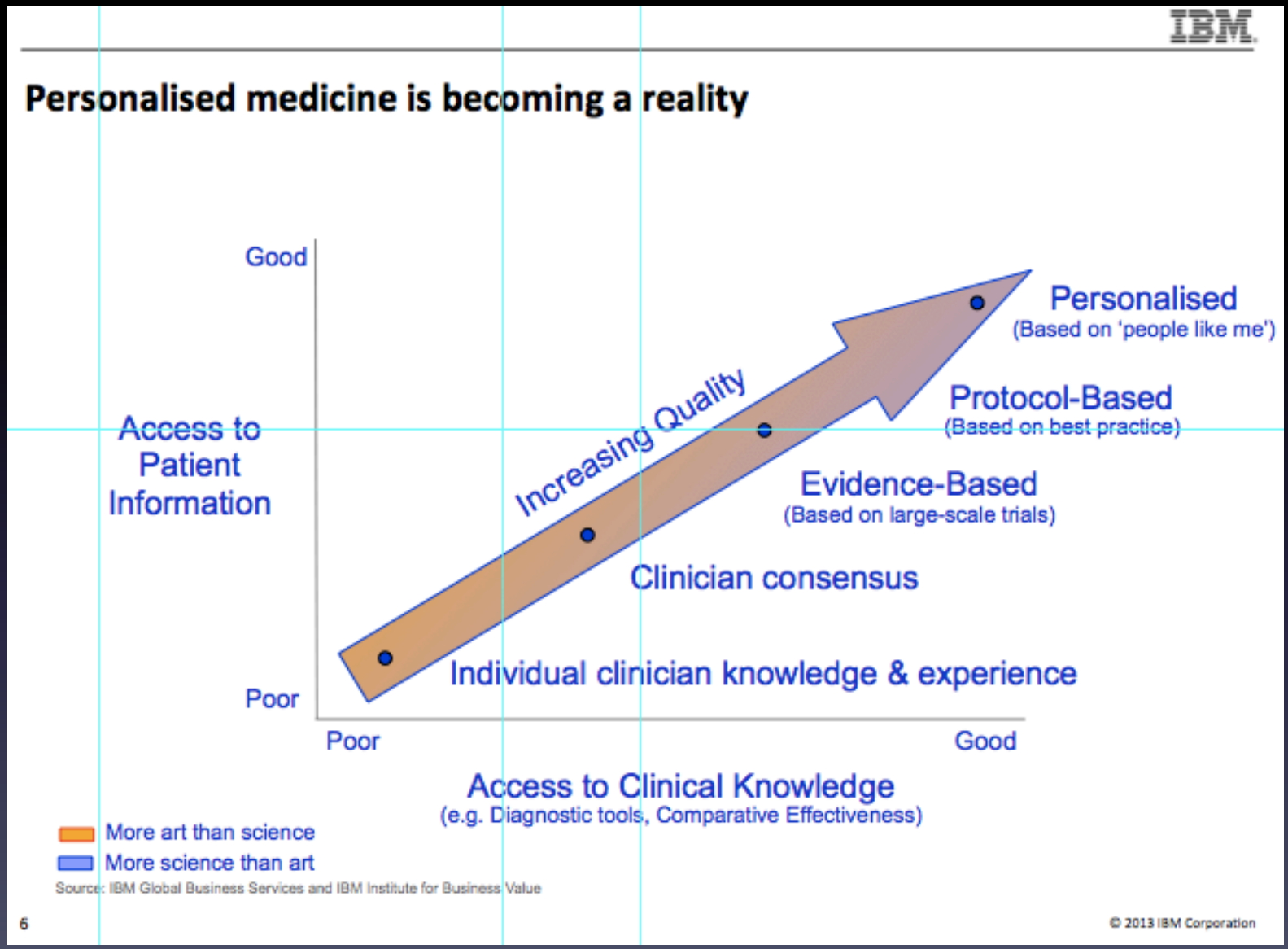
Consumer Expectations

"Where do you find information to make decisions about healthcare?"
The Internet & Doctors Rank Highest; Friends, Family and Media Follow



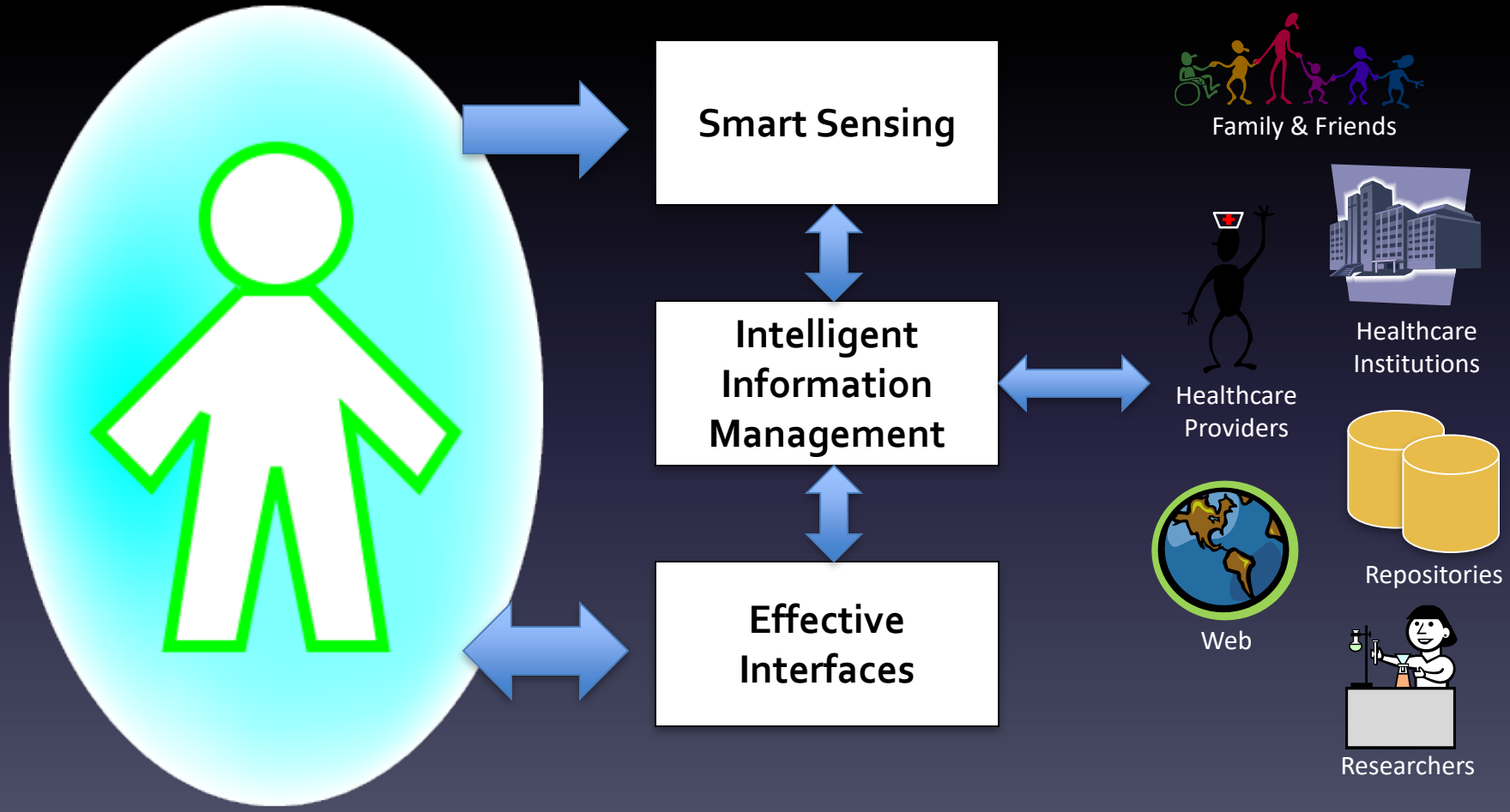
PricewaterhouseCoopers 2010

Personalized Medicine



Personalized Medicine

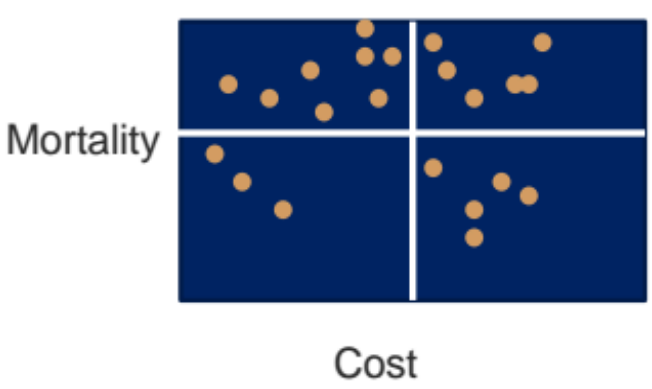
Putting the patient at the center of their health system

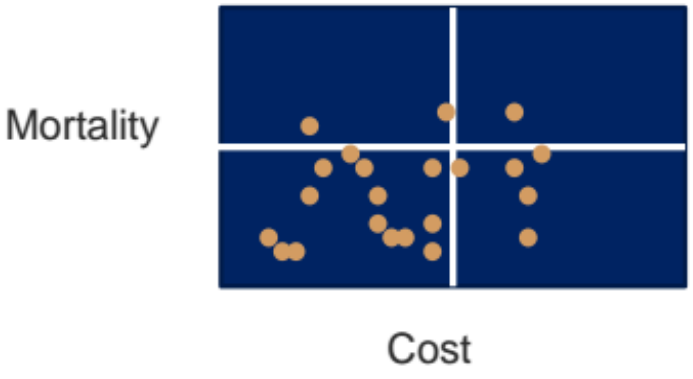


Personalized Medicine

CDS Transformation

Clinical Decision Support Today	Clinical Decision Support Tomorrow
Primary focus process: measures →	Primary focus: outcomes o LOS o Costs o Readmissions o Mortality
Venue focused →	Continuum of care
Not quadrant focused →	Quadrant focused

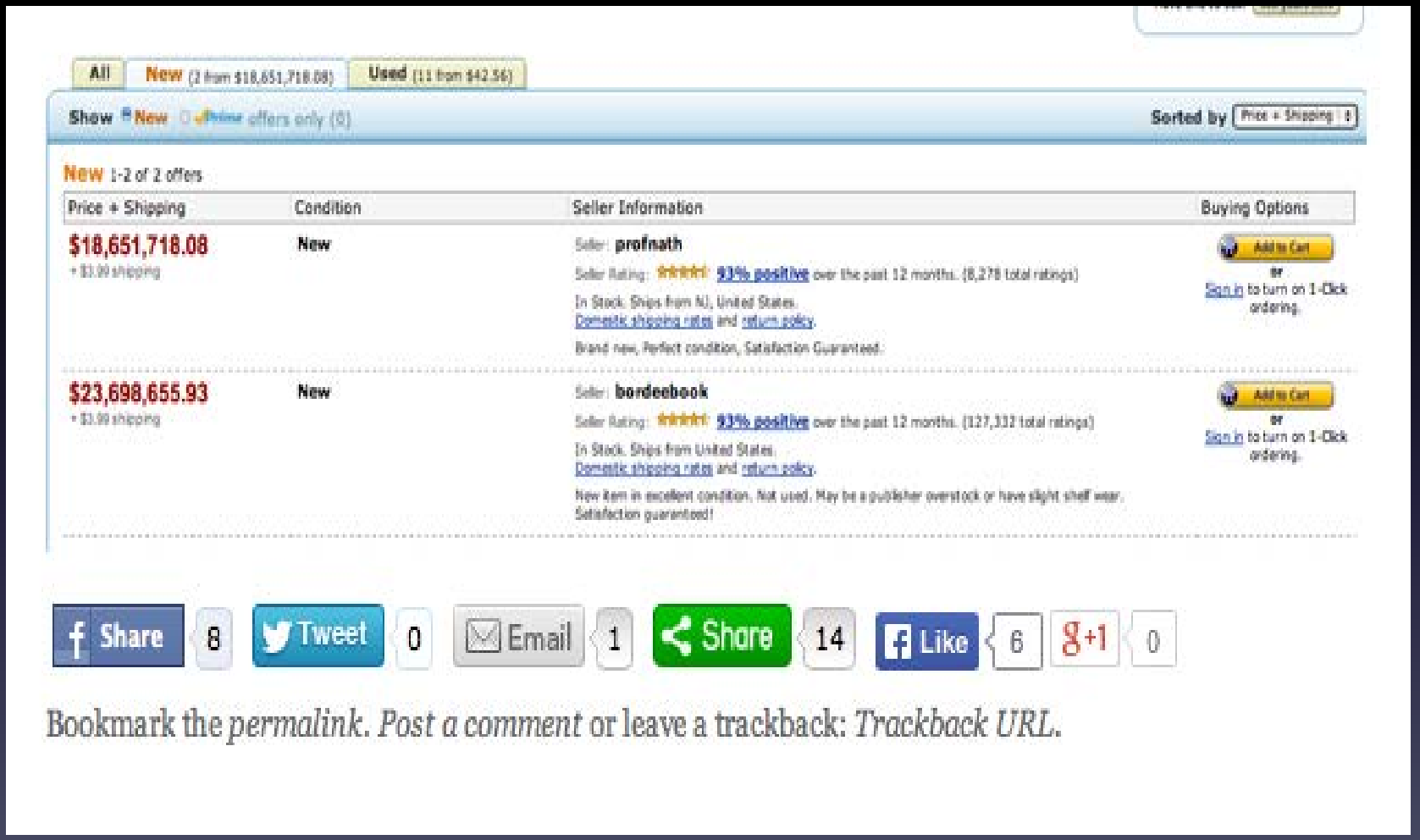




Why We Will Embrace CDSS (and perhaps why we shouldn't)

- Cost
- Convenience
- Confidence

Confidence (Misplaced!)



More Confidence (Misplaced!)

Why We Need CDSS

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

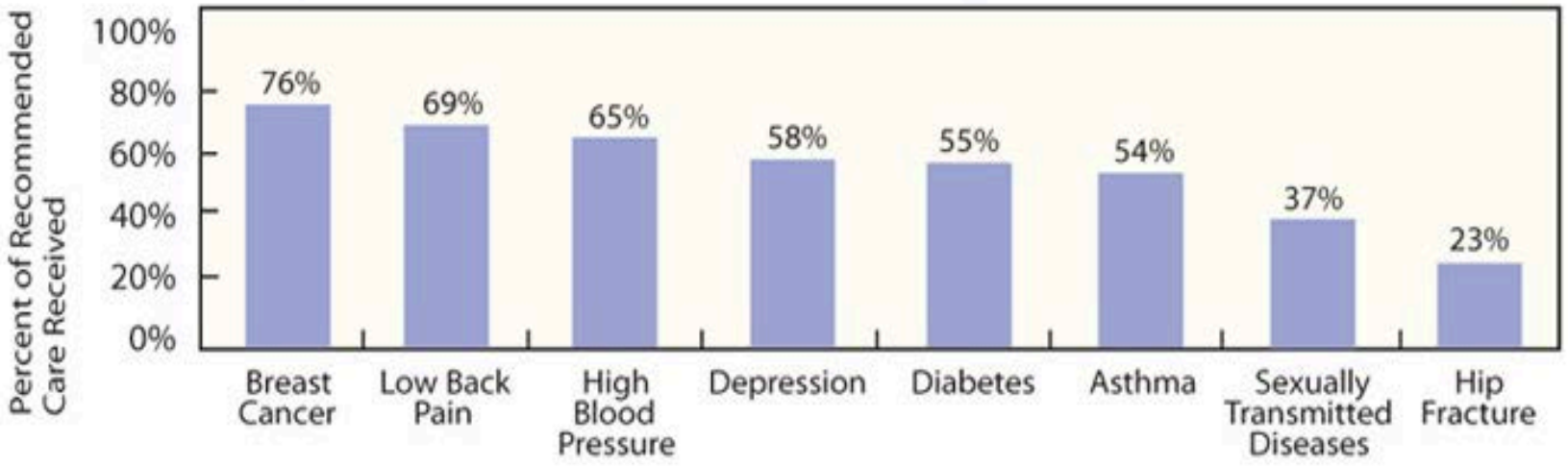
Clinical Procedure	Landmark Trial	National Use Rate
Flu vaccination	1968	55%
Pneumococcal Vac.	1977	36%
Beta Blocker After MI	1982	62%
Mammography	1982	62%
FOBT	1986	17%
Diabetic Foot Care	1993	20%

Balas EA, Boren SA. Managing clinical knowledge for health care improvement. In: Bemmel J, McCray AT, editors. Yearbook of Medical Informatics 2000: Patient-Centered Systems.

Why We Need CDSS

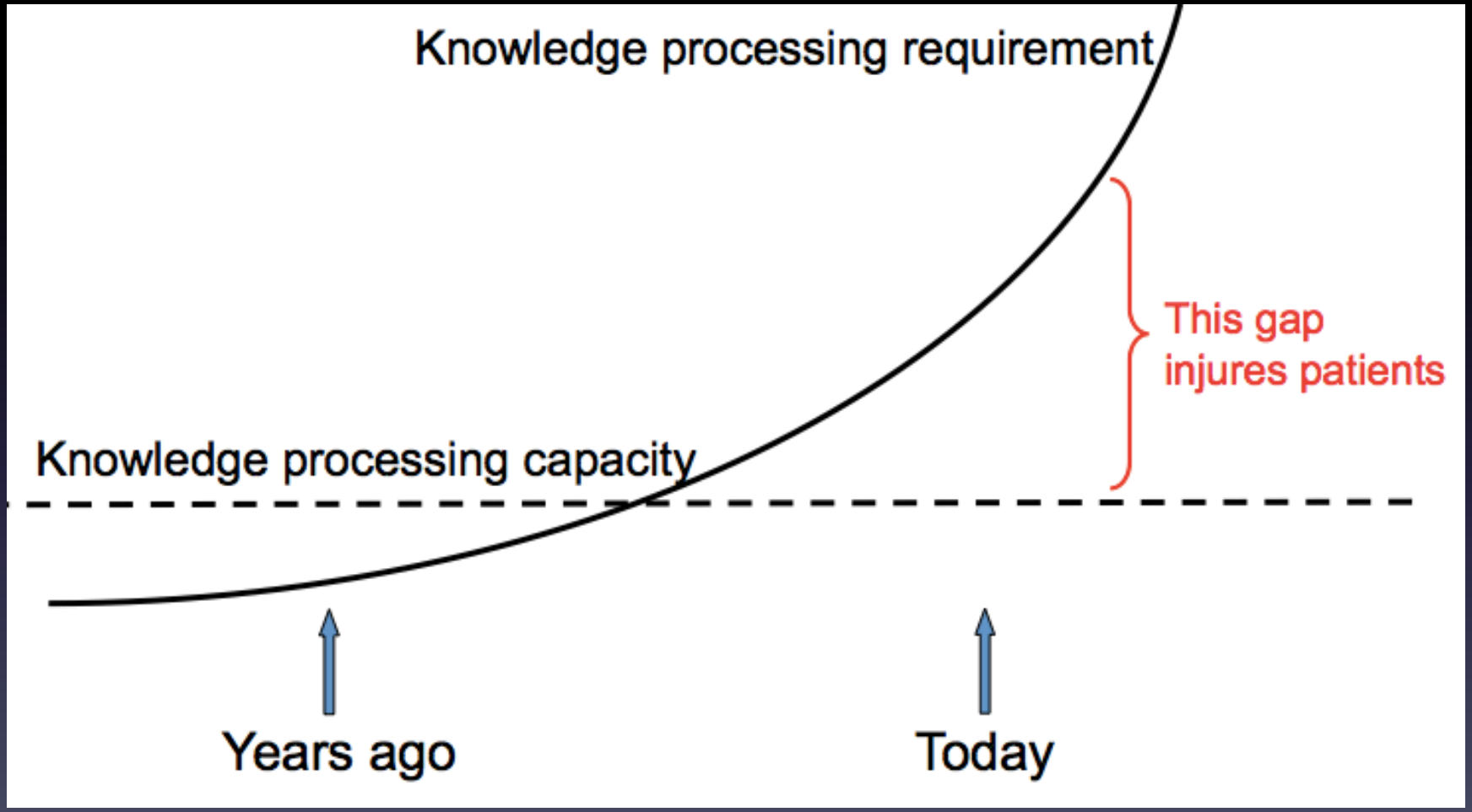
Figure 7:

Adults Receive Only Some of the Recommended Care for Many Common Conditions



Source: McGlynn, et al., New England Journal of Medicine, 2003

Why We Need CDSS

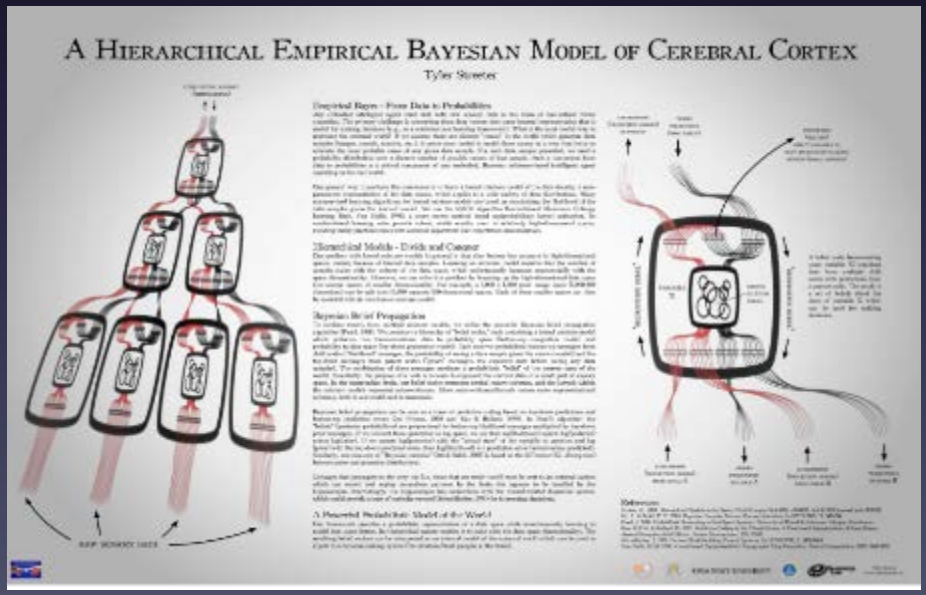


Computer Intelligence

- Artificial Intelligence
  - Machine Learning
    - Deep Learning

Artificial Intelligence

- Three Kinds
  - Narrow AI
    - Skilled at one task
      - IBM's Deep Blue
      - Watson
  - Artificial General Intelligence (AGI)
    - Skilled at a range of tasks
      - Human Level
  - Superintelligent AI
    - Machines are smarter than humans



Machine Learning

- A subdivision of AI
- Machines deciphering data
  - Commonly used today
    - Speech, object, and facial recognition
- Machines recognize patterns
  - Make predictions on their own
    - Deep Patient

Deep Learning

- A subdivision of Machine Learning
- Uses Machine Learning Techniques
  - Taps into Neural Networks
  - Mimic human decision making
  - Very data intensive
    - Alpha Go
      - October 2015

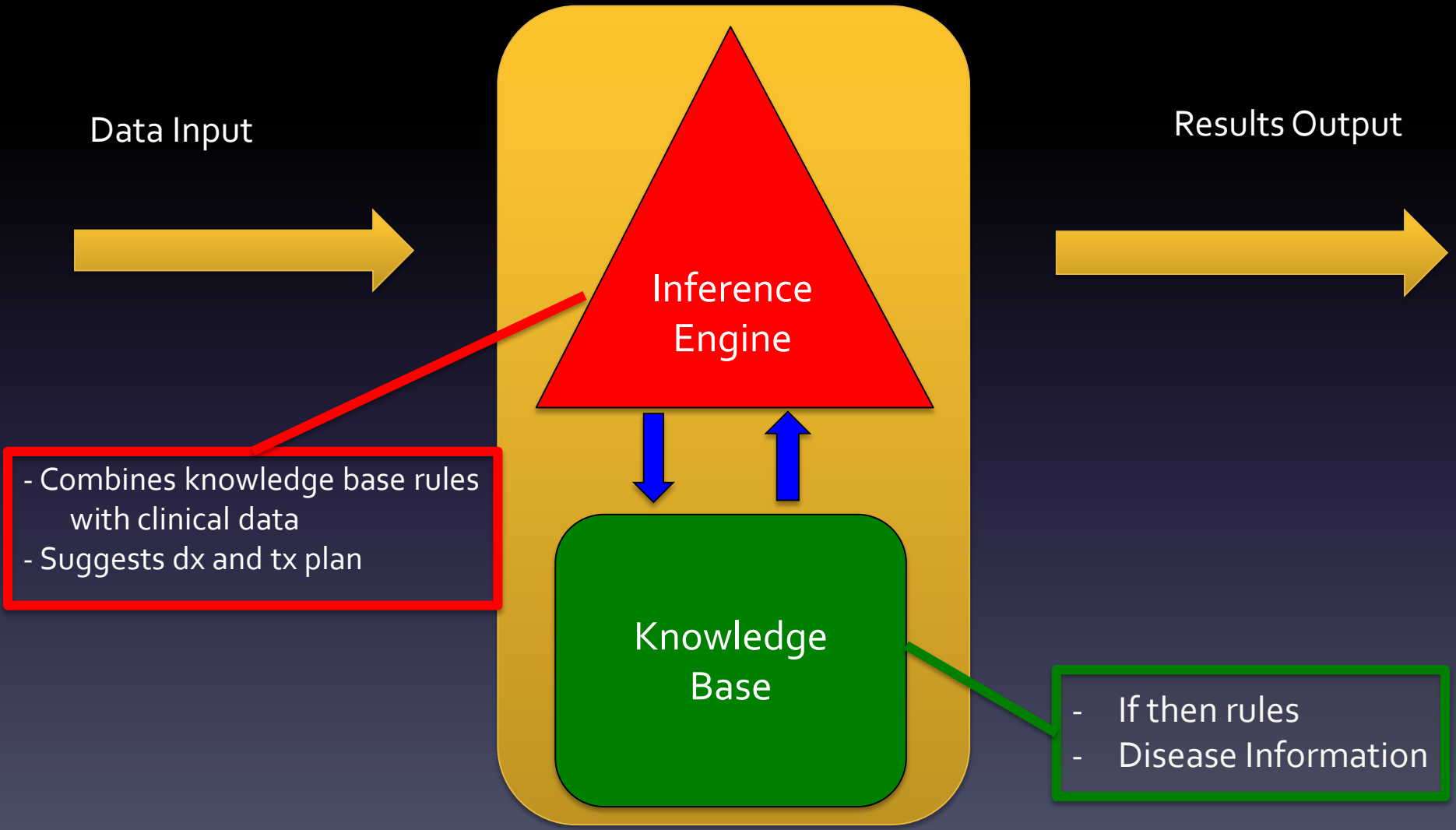
Clinical Decision Support (CDS) Defined

- A process designed to aid directly in clinical decision making
- Generate ***patient specific interventions***
- ***Presented to a decision making recipient or recipients***
- ***5 Rights of CDS***

CDS *Five Rights*

- Deliver the Right information
- To the Right person
- In the Right CDS intervention format
- Through the Right channel
- At the Right point in workflow

How Do CDS Systems Work?



http://www.intechopen.com/download/get/type/pdfs/id/18694

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

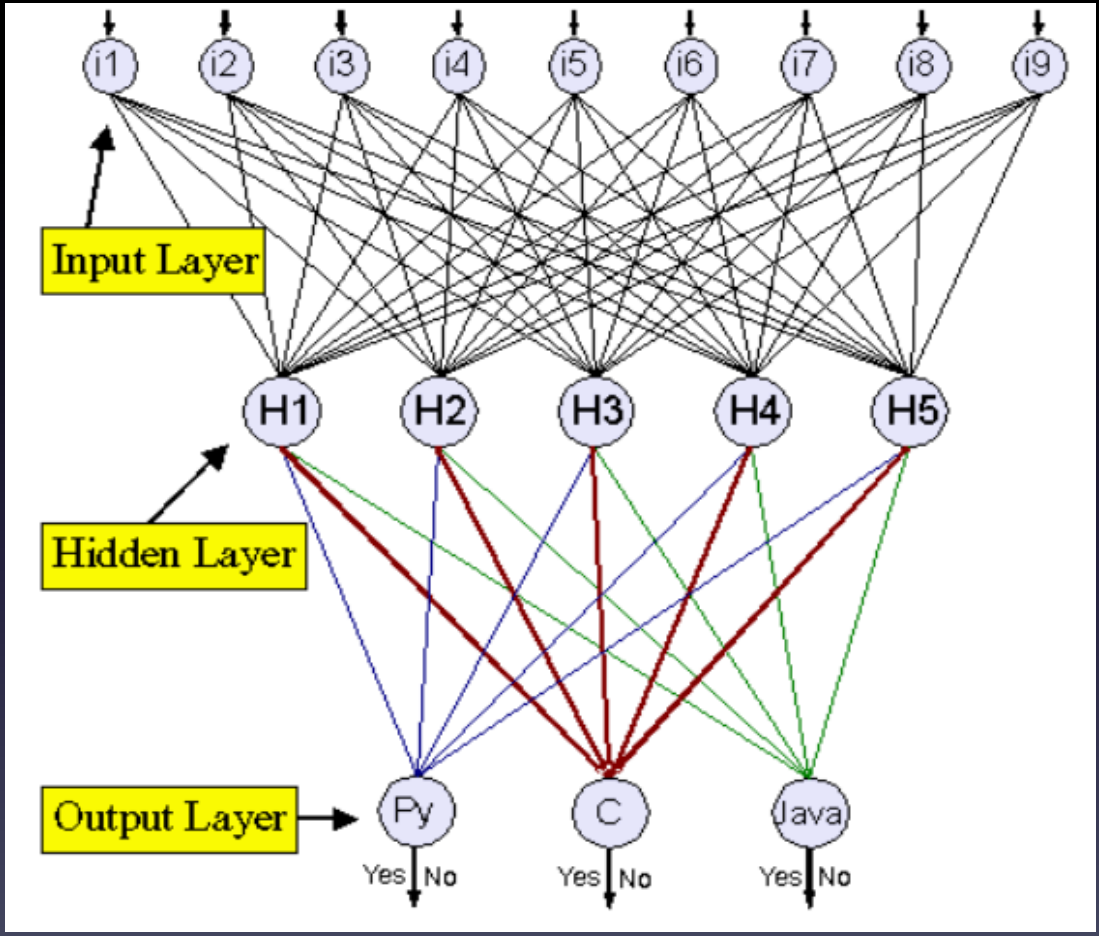
Neural Networks

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
  - Embedded in EMRs
- 2. Alerts
  - Patient Care Reminders
- 3. Referential Content
  - UpToDate
- 4. Nursing Care Plans
  - -Nurselabs.com
  - -Careplans.com
- 5. Drug Database
  - -Epocrates
  - -Medscape

Meaningful Use

Stages of Meaningful Use Have Occurred Over Five Years

2011-2012	2014	2016
Stage 1	Stage 2	Stage 3
Data Capture And Sharing	Advanced Clinical Processes	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 rul
  - **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

Meaningful Use and CDSS

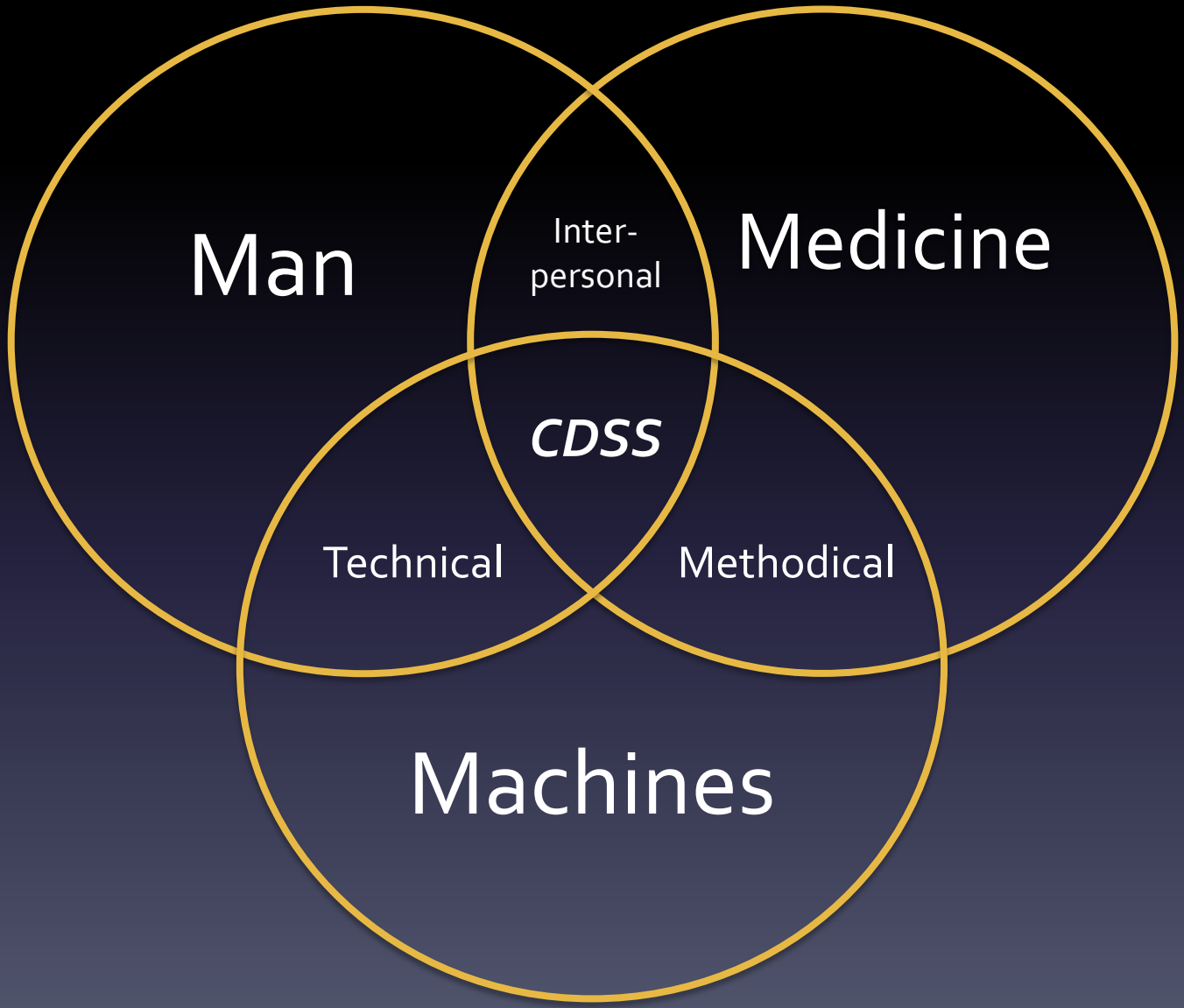
- Stage 3
- Measure 1:
  - Implement five clinical decision support interventions related to four or more clinical quality outcome measures
- Measure 2:
  - The EP, eligible hospital or CAH has enabled and implemented the functionality for drug-drug and drug allergy interaction checks for the entire EHR reporting period.

http://www.himss.org/ResourceLibrary/VSarticleDEV.aspx?ItemNumber=46311

Do CDSS Work?

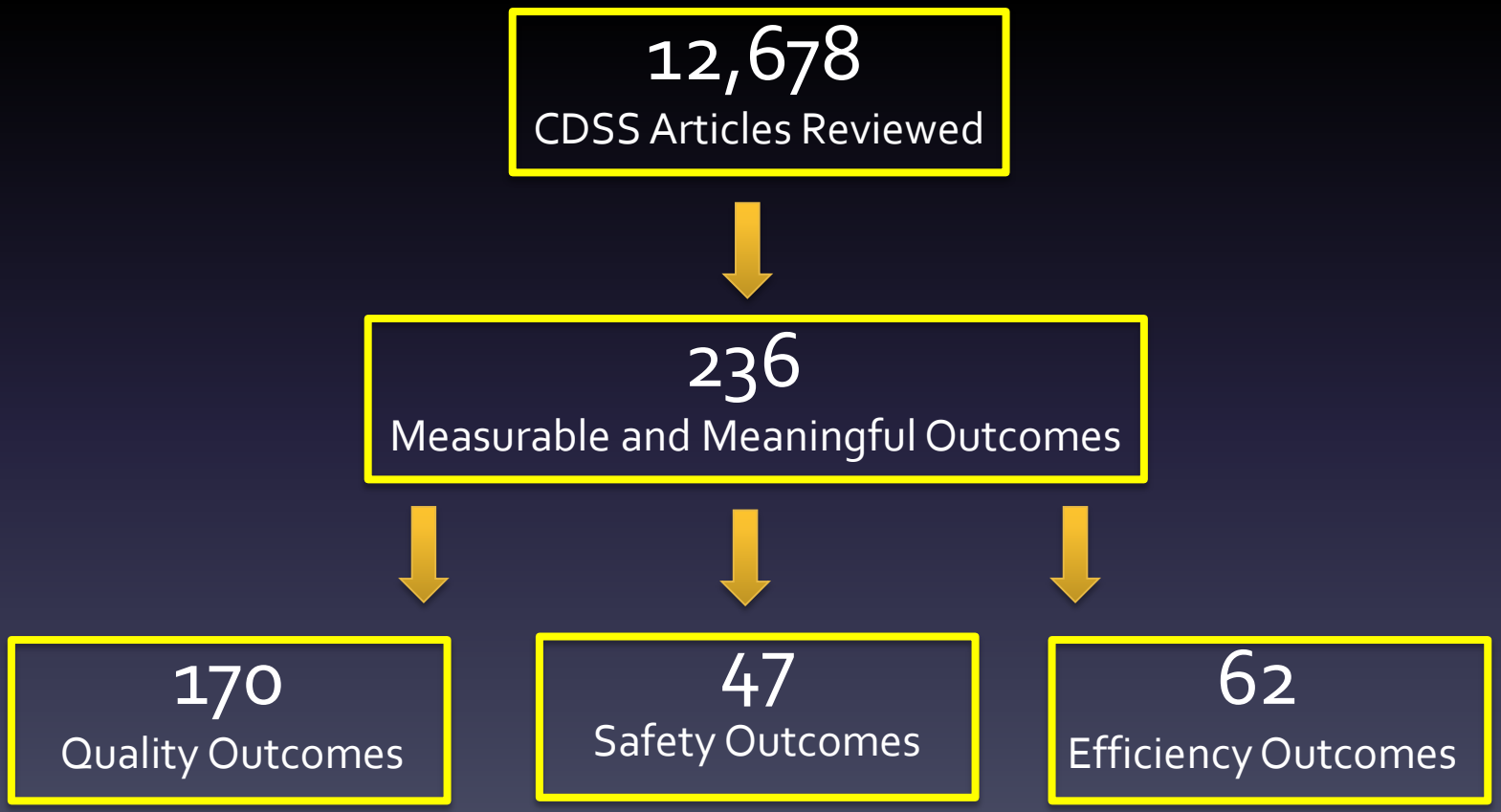
- Initial studies were not promising
- Reduction in ADEs were the earliest benefits
- Workflow and knowledge management problems hounded most systems
- The human/digital interface is tricky

Clinical Decision Making in the New World



CDSS Studied

Annals of Internal Medicine
January 2014



Ann Intern Med. 2014;160(1):48-54.
doi:10.7326/M13-1531

CDSS Studied

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

Meaningful Use Functionality	Outcome, *n*			
	Quality	Efficiency	Safety	All
Clinical decision support	257	91	69	417
Computerized provider order entry	63	66	60	189
Multifunctional health IT intervention	146	100	27	273
Patient care reminders	48	8	1	57
e-Prescribing	15	18	15	48
Patient access to electronic records	17	3	0	20
Health information exchange	5	10	0	15
Clinical laboratory test results	4	6	1	11
Medication lists	1	1	1	3
Electronic immunization registries	2	1	0	3
Other meaningful use*	15	6	0	21
All meaningful use	573	310	174	1057

Ann Intern Med. 2014;160(1):48-54. doi:10.7326/M13-1531

CDSS Is Working

Meaningful Use Functionality	Outcome Result, %				Total, *n*
	Positive	Mixed	Neutral	Negative	
Clinical decision support	65	17	11	7	142
Computerized provider order entry	63	16	12	9	91
Multifunctional health IT intervention	51	33	8	8	131
Health information exchange	64	30	0	6	33
Patient lists by condition	73	17	3	7	30
e-Prescribing	52	28	4	16	25
Patient access to electronic records	60	25	10	5	20
Patient care reminders	60	30	0	10	10
Other meaningful use functionalities†	55	36	9	0	11
Total meaningful use	60	24	9	8	493

Ann Intern Med. 2014;160(1):48-54. doi:10.7326/M13-1531

CDSS is Working

March 15, 2017

Use of Computerized Clinical Decision Support Systems to Prevent Venous Thromboembolism in Surgical Patients

A Systematic Review and Meta-analysis

Zachary M. Borab, BA[1]; Michael A. Lanni, BS[2]; Michael G. Tecce, DO[2]; et al

» Author Affiliations

JAMA Surg. Published online March 15, 2017.

The use of CDSS was associated with

- A significant increase in the rate of appropriate ordering of prophylaxis for VTE
- A significant decrease in the risk of VTE events

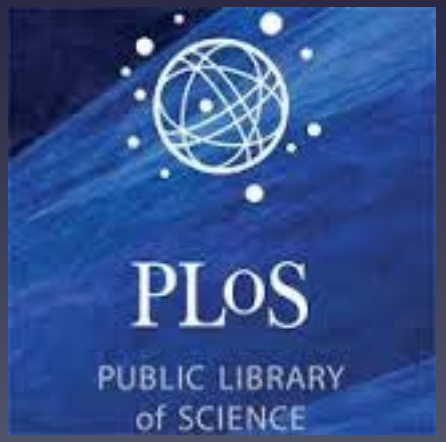
Three Key CDS Coming Soon to EMRs *(Future Fruit)*

- Differential Diagnosis (DDX) Generators
  - Assistance in DDX Generation
  - Reduction in Diagnostic Errors
- Integrated Healthcare Databases
  - Improved Connectivity
    - FHIR
- Personalized Medical Care
  - Human Genome Project
    - Prediction
    - Treatment Confidence

DDX Generators

- *"Programs which assist healthcare professionals in clinical decision making by generating a DDX based on a minimum of two items of patient data"*.

- The Effectiveness of Electronic Differential Diagnoses (DDX) Generators: A Systematic Review and Meta-Analysis
  - PLOS One Published: March 8, 2016
  - DOI: 10.1371/journal.pone.0148991



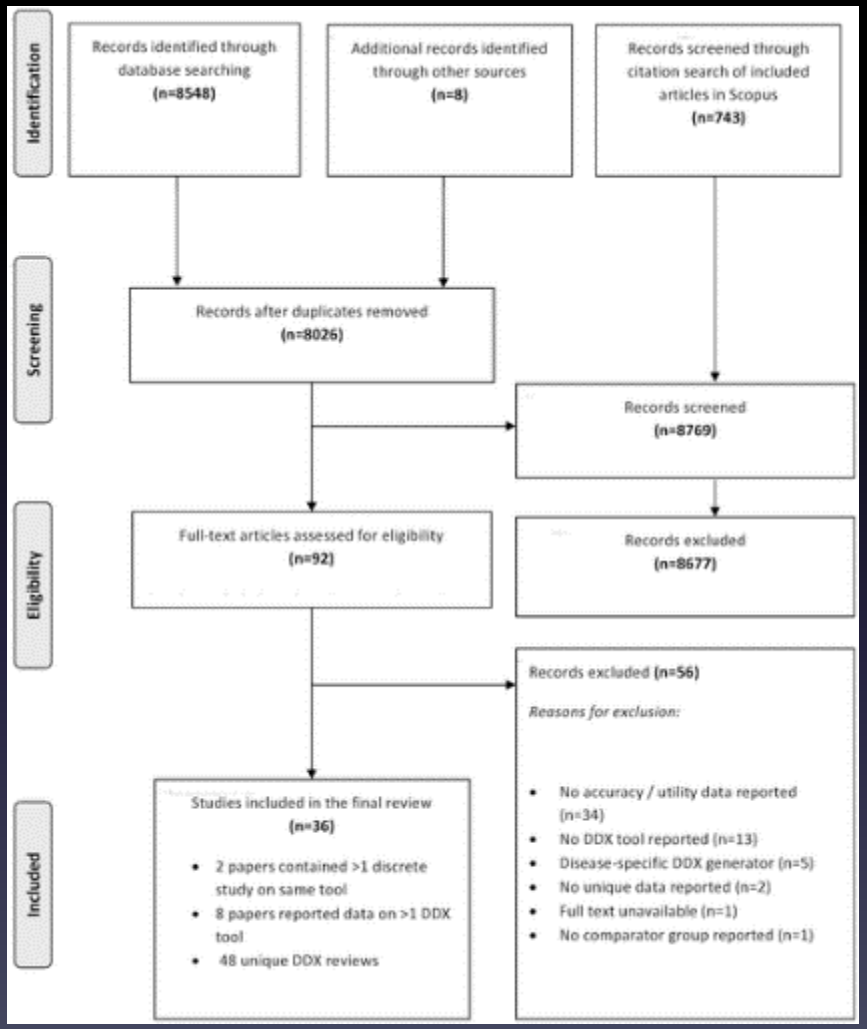
The Effectiveness of Electronic Differential Diagnoses (DDX) Generators: A Systematic Review and Meta-Analysis

Identify: 8548

Screening: 8026

Eligibility: 92

Included: 36



Riches N, Panagioti M, Alam R, Cheraghi-Sohi S, Campbell S, et al. (2016) The Effectiveness of Electronic Differential Diagnoses (DDX) Generators: A Systematic Review and Meta-Analysis. PLoS ONE 11(3): e0148991. doi:10.1371/journal.pone.0148991
http://journals.plos.org/plosone/article?id=info:doi/10.1371/journal.pone.0148991

DDX Generators Studied

- "Our findings demonstrate that DDX generators have the potential to
  - Improve diagnostic practice
  - Reduce diagnostic error
  - But there is currently insufficient evidence from the existing literature to recommend their routine use by clinicians".

Nicholas Riches, et al
The Effectiveness of Electronic Differential Diagnoses (DDX) Generators: A Systematic Review and Meta-Analysis
PLOS One Published: March 8, 2016
DOI: 10.1371/journal.pone.0148991

Integrated Healthcare Databases

- Healthcare data major problem
  - Increasingly digitized
  - Increasingly cloistered
- Connectivity and Privacy Issues
- Financial Issues
- FHIR to the rescue?

FHIR

Fast Healthcare Interoperability Resources

- A standard for exchanging healthcare information electronically
- Aims to simplify implementation without sacrificing information integrity.
- It leverages existing technology for exchanging data between healthcare applications.
- Major buy-in
- Major obstacles
  - BMJ blog March 2016
  - http://blogs.bmj.com/bmj/2016/03/10/steve-ruffenach-electronic-health-records-time-for-machines-to-start-sharing/

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,
New England Journal of Medicine 303,192-197. 1980

What does the future hold?

"However, in dealing with computers, nothing can be taken for granted. And clinical judgment counts for little unless it rests on a firm base of ordinary human judgment."

Marsden S. Blois, MD, FACMI

Clinical Judgment and computers, New England Journal of Medicine 303,192-197. 1980

What Must We Do?

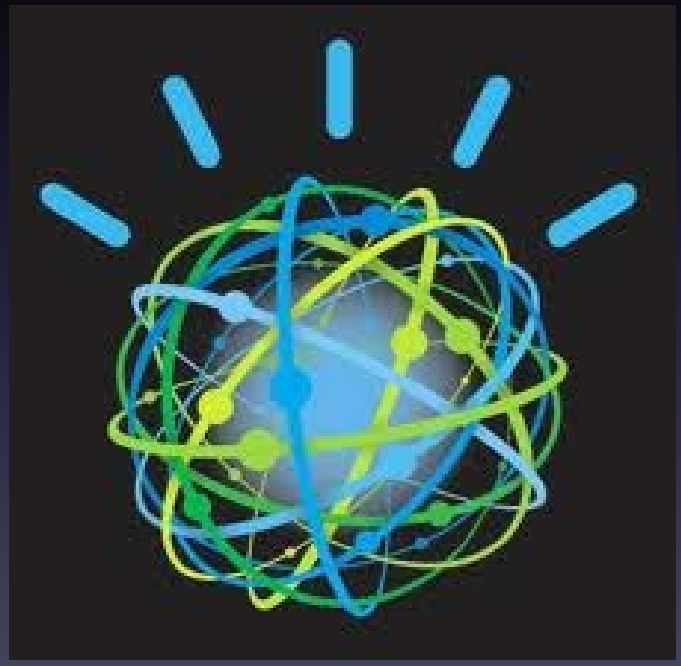
- **Illuminate**
  - Be wary of "machines taking over"
- **Evaluate**
  - Convenience trumps quality
  - Complacency is the enemy
- **Integrate**
  - Meaningfully use technology
- **Differentiate**
  - From machines
  - From the community

The successful clinician will cultivate and command expertise in areas that machines cannot perform

Empathy
Sympathy
Physical Contact
Self-awarenmess

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*



IBM Watson

Mayo Clin Proc. 2006; 81 (3): 338-334

Take Home Points

- ***"The important thing is not to stop questioning. Curiosity has its own reason for existing."***
  - Albert Einstein

The past is a foreign country.

They do things differently there.

L. P. Hartley, 1953

The future starts today,

not tomorrow.

Pope John Paul II, 2000