Medical Decision Making
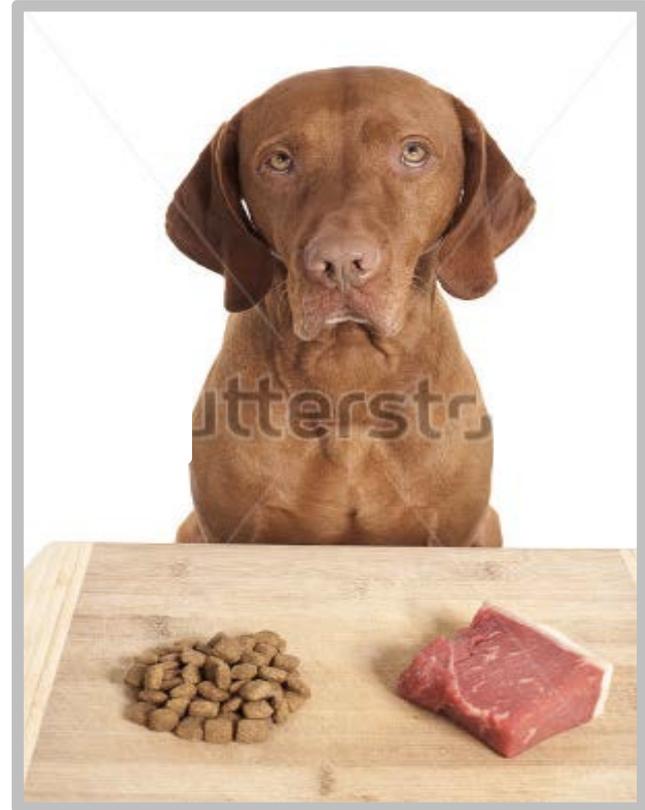## Priscilla Kincaid Smith Oration 2016

John Mills AO

Making decisions is common to humans and animals

Barron AB, Klein C, **What insects can tell us about the origins of consciousness**. PNAS 2016. PMID: 27091981
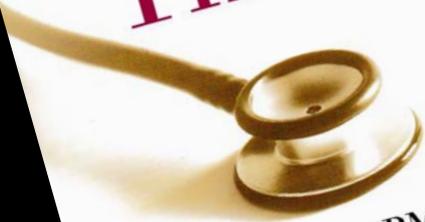
Decision making from A-Z

"Must reading for every physician who cares for patients and every patient who wishes to get the best care." — Time

NEW YORK TIMES BESTSELLER

How Doctors Think

JEROME GROOPMAN, M.D.

WITH A NEW AFTERWORD

The No.1 International Bestseller

'Astonishing'
DAILY MAIL

'Fascinating'
OBSERVER

blink

The Power of Thinking without Thinking

MALCOLM GLADWELL

THE NEW YORK TIMES BESTSELLER

THE CHECKLIST MANIFESTO

HOW TO GET THINGS RIGHT

ATUL GAWANDE

BESTSELLING AUTHOR OF BETTER AND COMPLICATIONS

PICADOR

Medical Decision Making

The Society of Medical Decision Making has its own journal, society & meetings

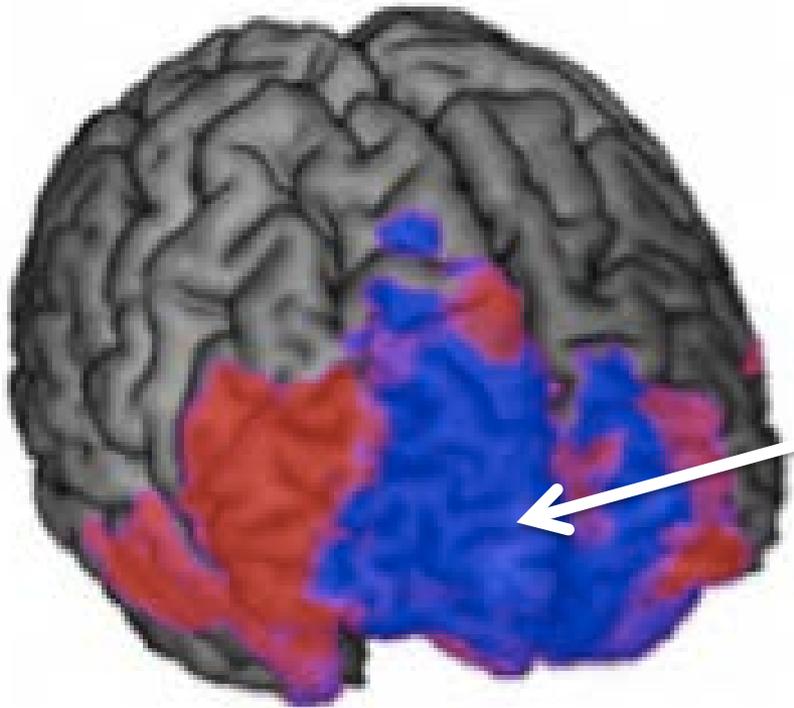# Brain segments involved in decision making

Regions of the brain associated with value-based decision-making include the orbitofrontal, ventromedial, and frontopolar cortex – the areas in which "… we give value to choices and how we make decisions"

Gläscher J, Adolphs R, Damasio H, *et al.*
Proc Natl Acad Sci U S A. 2012; 109:14681.

NEW YORK TIMES BESTSELLER

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HOW TO GET THINGS RIGHT

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ATUL GAWANDE

BESTSELLING AUTHOR OF *BETTER* AND *COMPLICATIONS*

Today's Presentation

- A short history of "formal" decision making and the elements involved

- A short history of medical decision making

- Models of medical decision making

- Evidence for erroneous medical decisions

- How mistakes in medical decision may be circumvented

- A look into the future of medical decision-making

A short history of decision making

- Ancient Greek philosophers did not have a rational or rule-based framework for decision making, although they recognized it as an important activity

- Greek philosophers **did not recognize probability theory**[§], which is key to rigorous decision making

- But they did recognize good *versus* bad decisions and what the outcomes might be.

[§]a branch of mathematics dealing with random distributions – e.g. thrown dice

".. even if the event turns out contrary to one's hope,
still, one's decision was right,
even though fortune has made of it no effect;
whereas, if a man acts contrary to good counsel,
although by luck he gets what he had no right to expect,
his decision was not any the less foolish."

Herodotus VII: 10
c. 484–425 BC
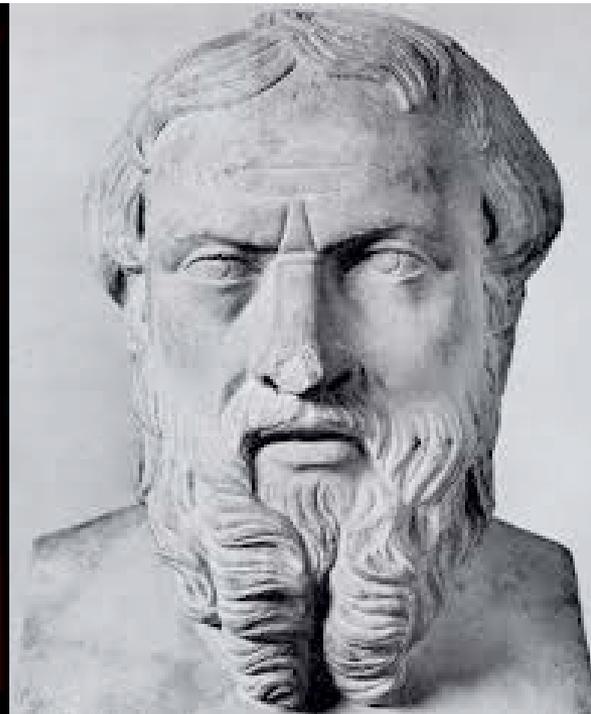
The first understanding of probability theory came in the mid-17th Century

- Correspondence between **Blaise Pascal** & **Pierre de Fermat** led to the discovery of the theory of probability

- Their correspondence caught the eye of a professional gambler, who was curious to know if they could predict the outcome of thrown dice, thereby demonstrating that the mathematics of probability theory could have practical uses.

   "if a pair of fair dice are thrown 24 times, what is the likelihood of getting at least one pair of 6's?" (49%)

2008 Db 10000
Inventor of mechanical calculator
Blaise Pascal
(1623-1662)
S. TOMÉ E PRÍNCIPE

Pierre de Fermat
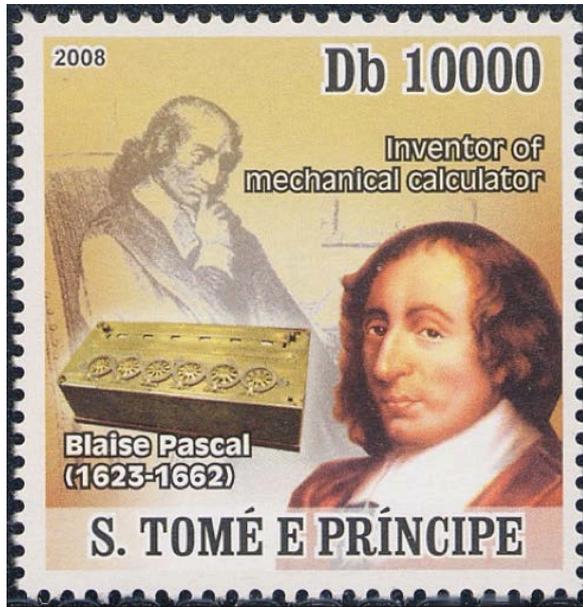
La Logique, ou l'art de Penser, a book by
Antoine Arnauld & **Pierre Nicole**
(French Catholic monks, subsequently accused of heresy)
first defines **the principle of maximizing expected value from a decision**.

"To judge of what we ought to do to obtain a good [outcome] &to avoid an evil [outcome], it is necessary to consider

not only the good and evil in themselves, but to regard geometrically

the proportion which all these things have, taken together."

Arnauld

Nicole
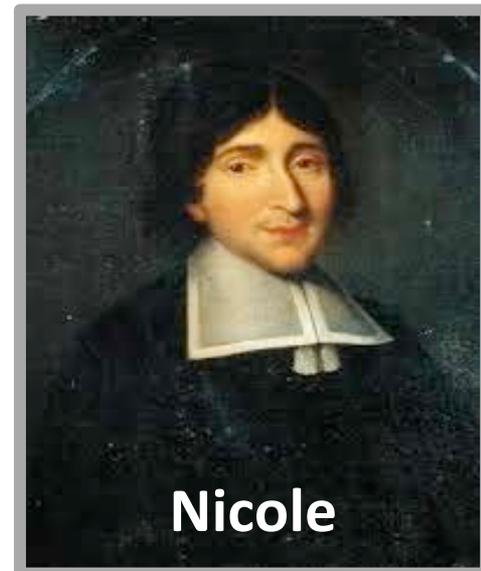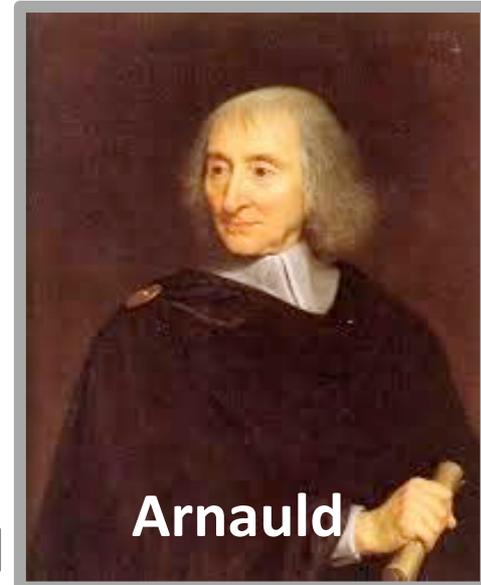
Modern decision theory did not develop until the first third of the 20th Century

Ramsey
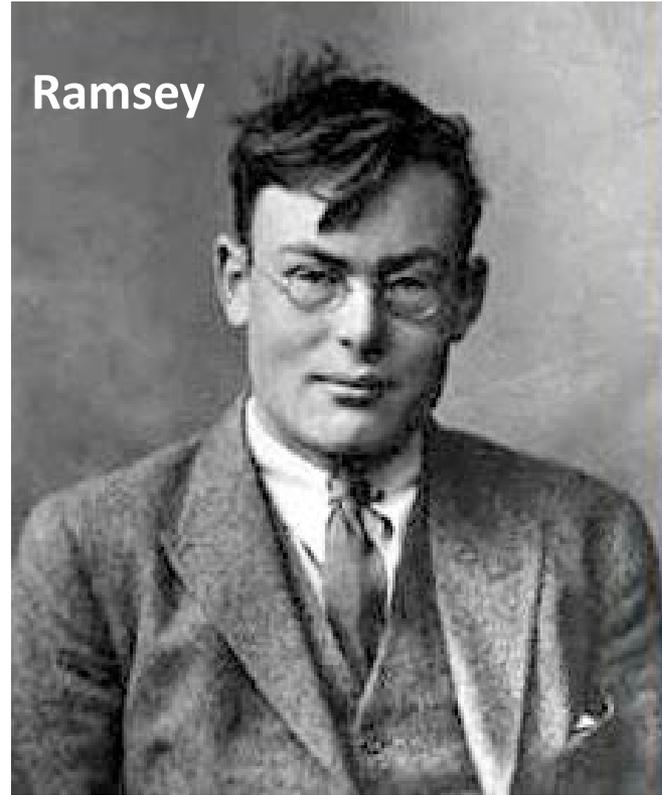
- **Frank P. Ramsey**, a Cambridge University philosopher, published *Truth & Probability*, proposing a set of 8 axioms for decision-making.

- When used by a decision maker, these would ensure that outcomes would be compatible with maximizing expected value.

- He also defined the concept of "subjective" probabilities and devised a way of quantifying them.

This essay is still available, cited 2544 times.

Leonard Jimmie Savage, *The Foundation of Statistics* (1954) Still in print
- Added to the concepts of subjective and personal probabilities, Bayesian statistics .

"Formal" decision-making theory: four core elements

- **Decision maker**: the person or persons making the decision – the "deciders"

- **A set of alternatives** that the decider(s) must choose from when making the decision

- **The state of all things to be included** when the decider(s) consider the alternatives

- **The outcome** (which may or may not be what the deciders) wanted.

Making a decision

- The woman is the sole <u>decider</u>
- Her <u>alternatives</u> are:
  - to turn L (a long trip)
  - or R (a short trip)
  - (other alternatives not being considered – do nothing, go back, etc.)
- The <u>states she must consider</u>:
  - which direction has the best view;
  - does she have the correct shoes to go L;
  - will it rain….
- The <u>outcome</u> will be that she goes either L or R
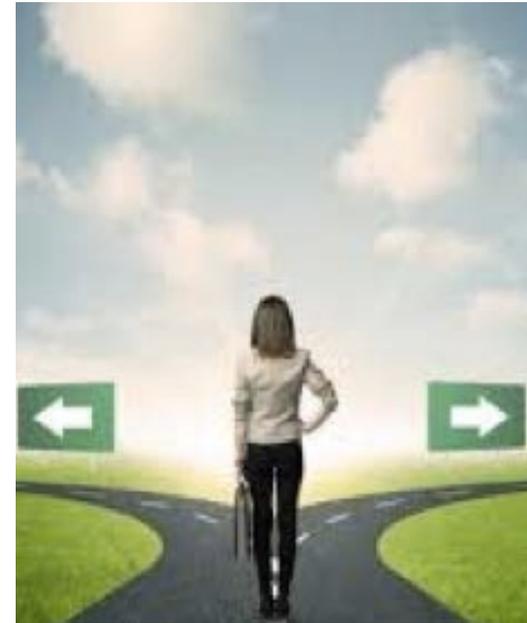
History of medical decision making

- **The "beneficence" or "paternalistic[§]" relationship** between doctor and patient
  - from the time of Hippocrates until ~50 years ago

- The doctor, almost invariably male and often alone, was in complete control – "doctor knows best"
  - There was little or no allowance for the patient's wishes

- **"First do no harm"** – an ethical manifest for doctors to act solely for the benefit of their patients

- **"Benevolent deception"**
  - With-holding selected information from the patient (e.g. cancer Dx).
  - **Mondeville** (c. 1260 – 1316) said, **"promise a cure to every patient, but tell the parents or friends if there is any danger."**
  - persists in some cultures even today.

Will JF, Chest 2011; 139:669; 1491; [§]Emanuel EJ, JAMA 1992; 267:2221

Dr Benjamin Rush (1747 – 1813)

- Dr Rush (and mentor, Dr John Gregory) advocate for disclosure to selected patients, presuming they will be enlightened and will then comply graciously with the doctor's orders

- However, Rush remained an advocate of "beneficence"
  - he favored the "inflexible authority" of the doctor over patients
  - patients should "never oppose" the doctors' advice.

Will JF, Chest 2011; 139:669; 1491
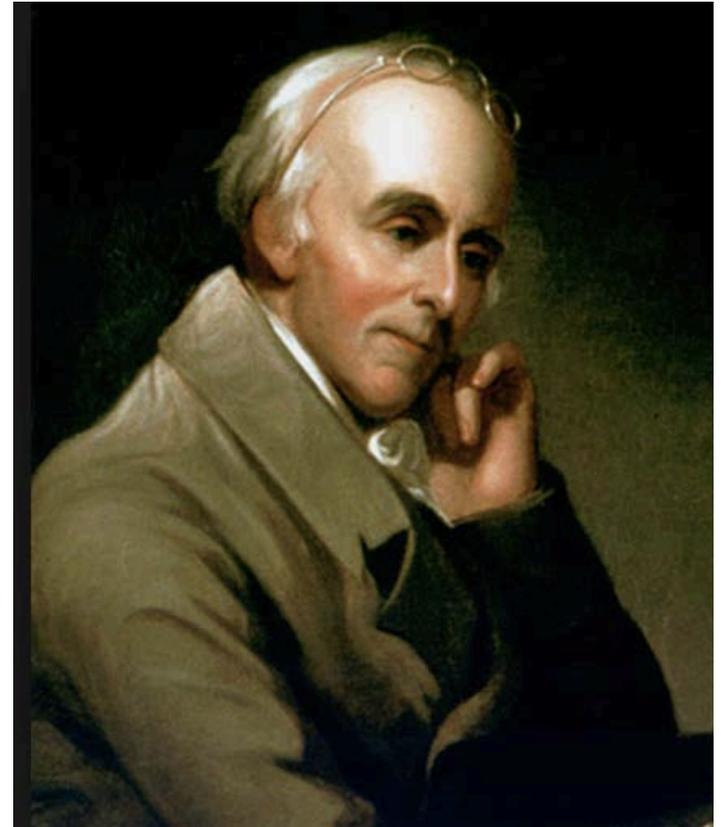
Dr Thomas Percival (1740 – 1804)

- Rush & Gregory's ideas that patients should be informed were not widely accepted in Europe

- **Percival** – another of Gregory's students, writes the first treatise on medical ethics and a Code of Medical Ethics
  - but continues to follow the "beneficence code" and remains a staunch advocate of "benevolent deception"

- His teachings regarding medical ethics were taken up by Australia & Canada

- Percival's **Code of Medical Ethics**
  - adopted as the first physicians' code of ethics by the newly-minted American Medical Association (1847)
- Some of Percival's language remained in the AMA code until 1980
- Even today, the AMA code doesn't mention "shared decision making"

CODE OF

MEDICAL ETHICS

OF THE

American Medical Association.

ORIGINALLY ADOPTED AT THE ADJOURNED MEETING OF THE NATIONAL MEDICAL CONVENTION IN PHILADELPHIA,

MAY, 1847.

CHICAGO:
AMERICAN MEDICAL ASSOCIATION PRESS.

Relevant NHMRC publications and information

Consumer engagement in research
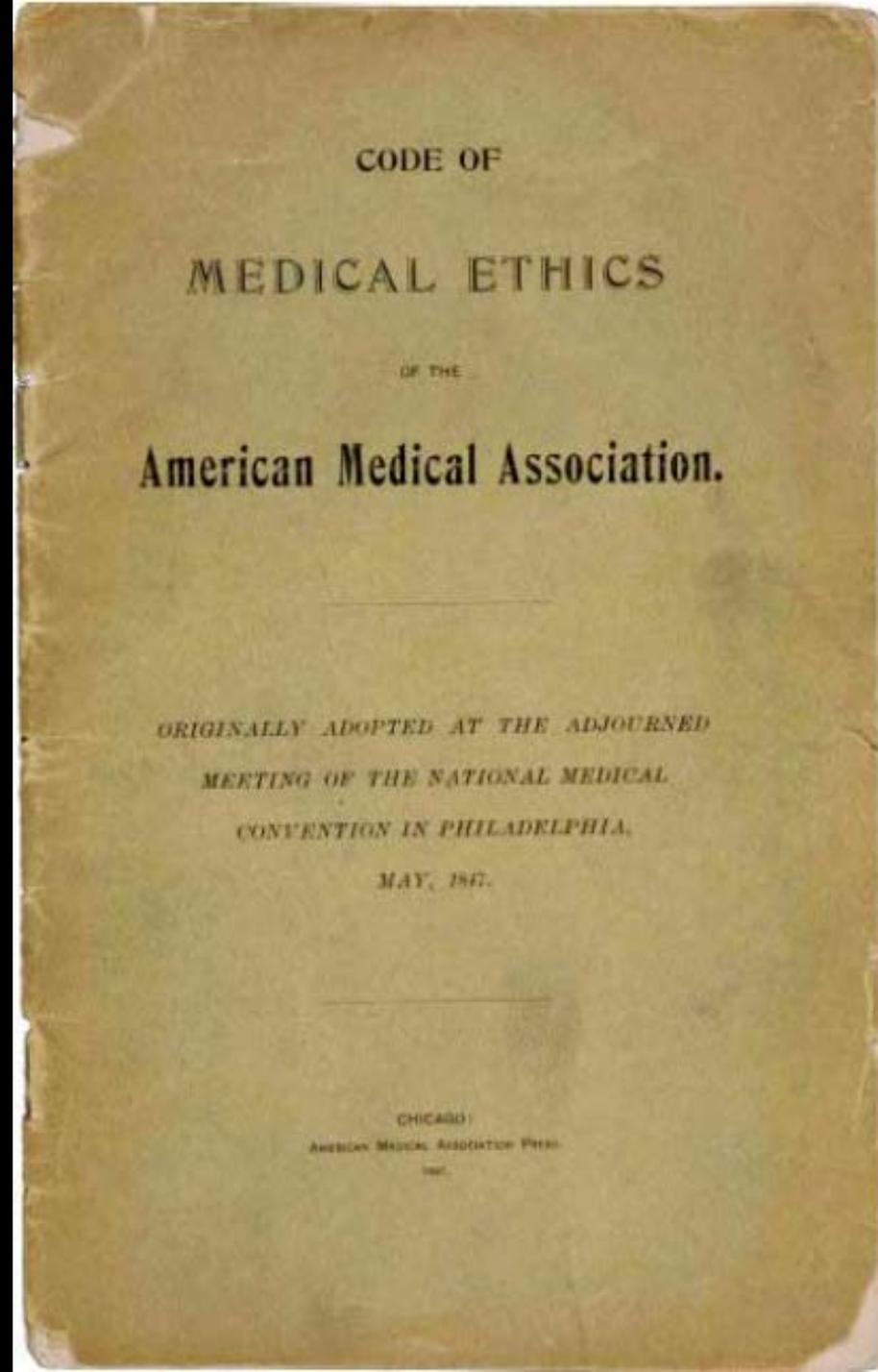
> Statement on Consumer and Community Participation in Health and Medical Research (the Statement on Participation) (2002)

> Cultural Competency in Health (2006): A guide for policy, partnerships and participation

Ensuring health advice has the end user in mind

> General Guidelines for Medical Practitioners on Providing Information to Patients (2004)

> Communicating with Patients: Advice for Medical Practitioners (2004)

Promoting dialogue between consumers and health professionals

> The Toolkit for Making Decisions About Tests and Treatments: a Guide to Better Communication Between Health Consumers and Health Professionals (2005)

Consumer involvement in the development of Guidelines

> Procedures and requirements for meeting the 2011 NHMRC standard for clinical practice guidelines (2011 NHMRC standard)

The rise of patient autonomy in medicine in the mid-20th Century

- **Experimentation on humans attracted the ire of AMA**

- Lawsuits against doctors in the US between 1905 -1914 established the need for patient consent

- This was supported by the Nuremberg trials after WW2 in response to German "clinical trials, resulting in the **Nuremberg Code**
  - stated the ethics principles for human experimentation and specifically the requirement for informed consent

- **Despite progress, clinical trials & human experimentation continued**
  - without consent of the subjects
  - or on people incapable of giving consent (e.g. children, prisoners).

- Listed >20 studies for which no appropriate consent was obtained and where science was often lacking e.g.

- Strep throat was known to cause rheumatic fever
  - despite that a study of penicillin vs placebo was done, n=109

- Chloramphenicol was known to cause aplastic anemia
  - despite that 38 healthy subjects were treated with high-dose chloramphenicol solely to study the effect on hematopoesis

- Orphaned children were infected with hepatitis B virus (unknown then) to see how long they remained infectious

- Live cancer cells were injected into 22 subjects to see what happens; the subjects were told they were getting "cells"

Beecher HK, NEJM 1966; 274:1354-60.

Doctor autonomy is challenged: 1970 and onwards

- **Public outrage** around consent-free clinical trials

- Led to patients no longer losing confidence in doctors, prompting *ad hoc* pt intervention in medical decision making

- **Belmont Report:** The US National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research established in 1974,
  - Responding to the Tuskegee syphilis experiments in 1972
  - Enforced full consent processes for subjects in clinical trials
  - The decision that **prisoners** should not participate in research at all, unless it was directly related to their wellbeing
  - A similar decision for those deemed **"mentally infirm"**

"Shared Decision-Making" Arrives!

President's Commission for the Study of Ethical Problems in
Medicine and Biomedical and Behavioral Research
Suite 555, 2000 K Street, N.W., Washington, DC 20006 (202) 653-8051

October 21, 1982

- **This Commission** was the first to articulate the concept of "shared decision making" between doctors and patients

- "Ethically valid consent is a process of shared decision-making based upon mutual respect and participation"

- The Commission also rejected the concept of benevolent deception, stating clearly that all medical information should be given to the patient, with only rare exceptions.

Models of Medical Decision Making

Models of medical decision making, mainly but not solely for diagnosis

Model 1

Analytic, hypothetical-deductive, deliberative:
a la Sherlock Holmes

- Serial hypothesis testing
- Probability testing
- Evidence-based
- Requires detailed information to maximize certainty
- Biases may skew output

Model 2

Intuitive, heuristic:

- Pattern recognition
- Leads to single diagnosis
- Experience improves efficiency
- Overconfidence is a flaw
- Uncertainty does not retard decisions
- Allows mop-up by Model 1 methods

An example of heuristic diagnosis using an algorithm

- Rural hospital in Michigan
  - **Cardiac ICU (CCU) is overwhelmed with patients who don't have AMI**

- Univ Michigan IT : **Heart Disease Predictive Instrument**
  - 50 probabilities, logistic regression result via pocket calculator
  - Not embraced!

- Green & Muhr GPs : a **simple heuristic "Fast & Frugal Tree"**

- **Heuristics are simple decision strategies**
  - Decision making algorithms
  - Practical method not guaranteed to be perfect
  - Sufficient for immediate goal
  - Mental short cuts that ease the cognitive load of making a decision

Marewski JN *et al.,* Dialogues Clin Neurosci. 2012;   Green & Muhr *J Fam Pract 1997*

Heuristic Decision Path: "Fast & Frugal Tree"
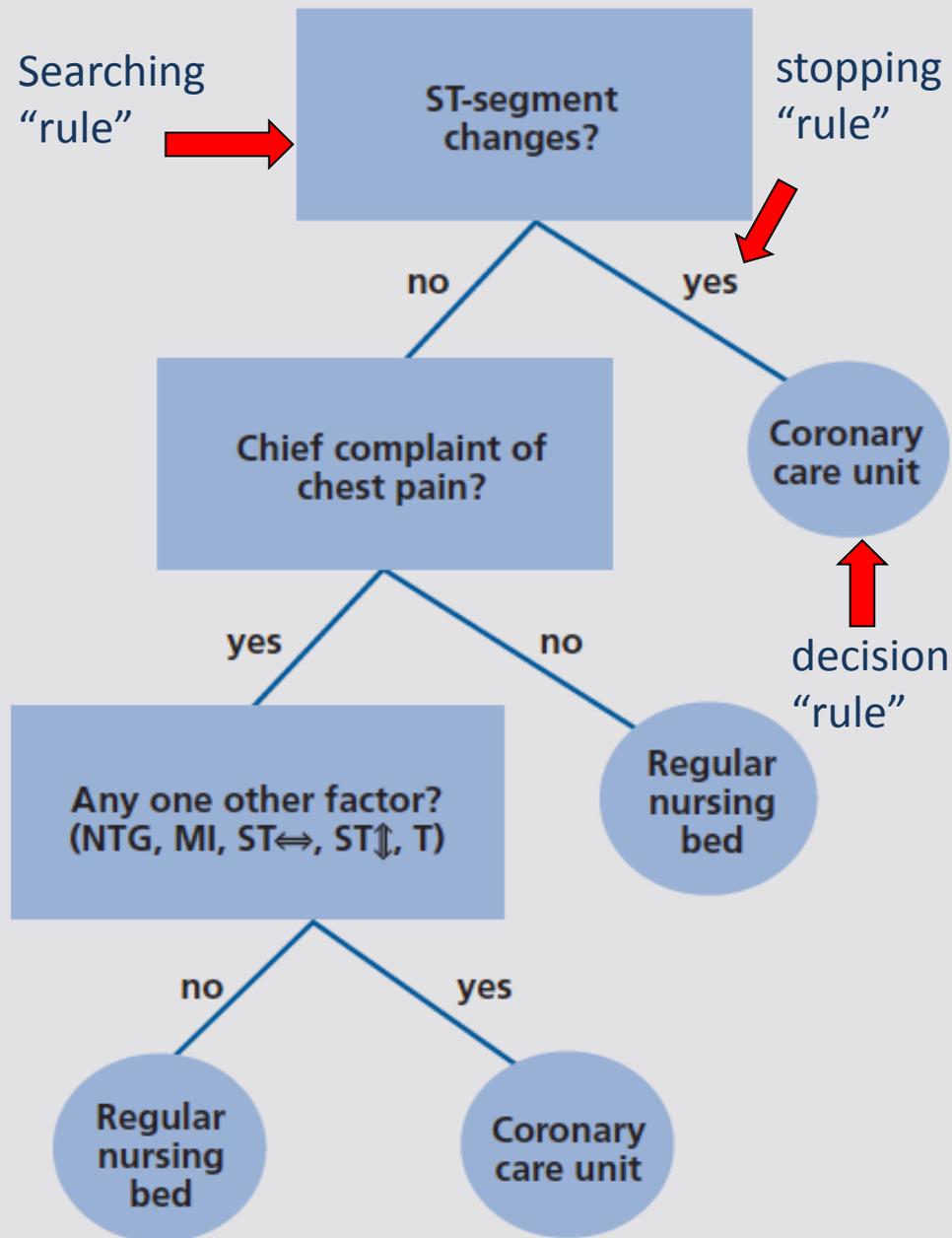
Heuristic Decision Path
"Fast & Frugal Tree"
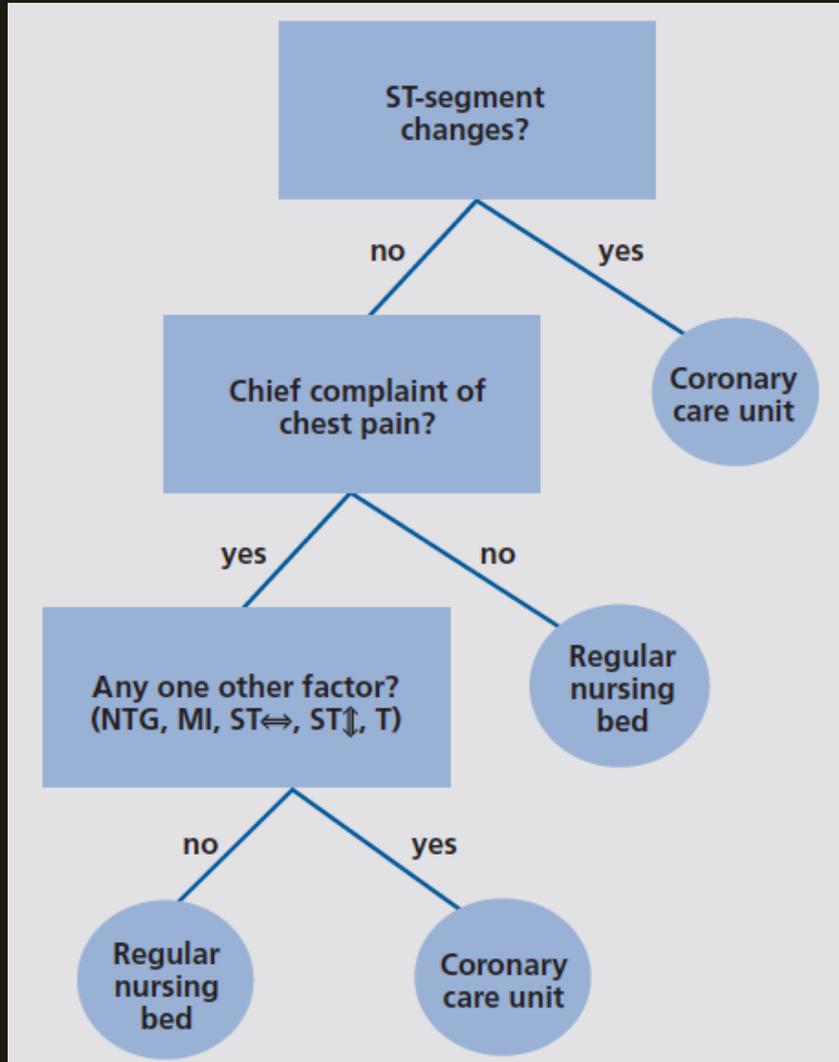
Outcome by Strategy:
Analytic –deductive vs heuristic

Marewski & Gigerenzer, 2012
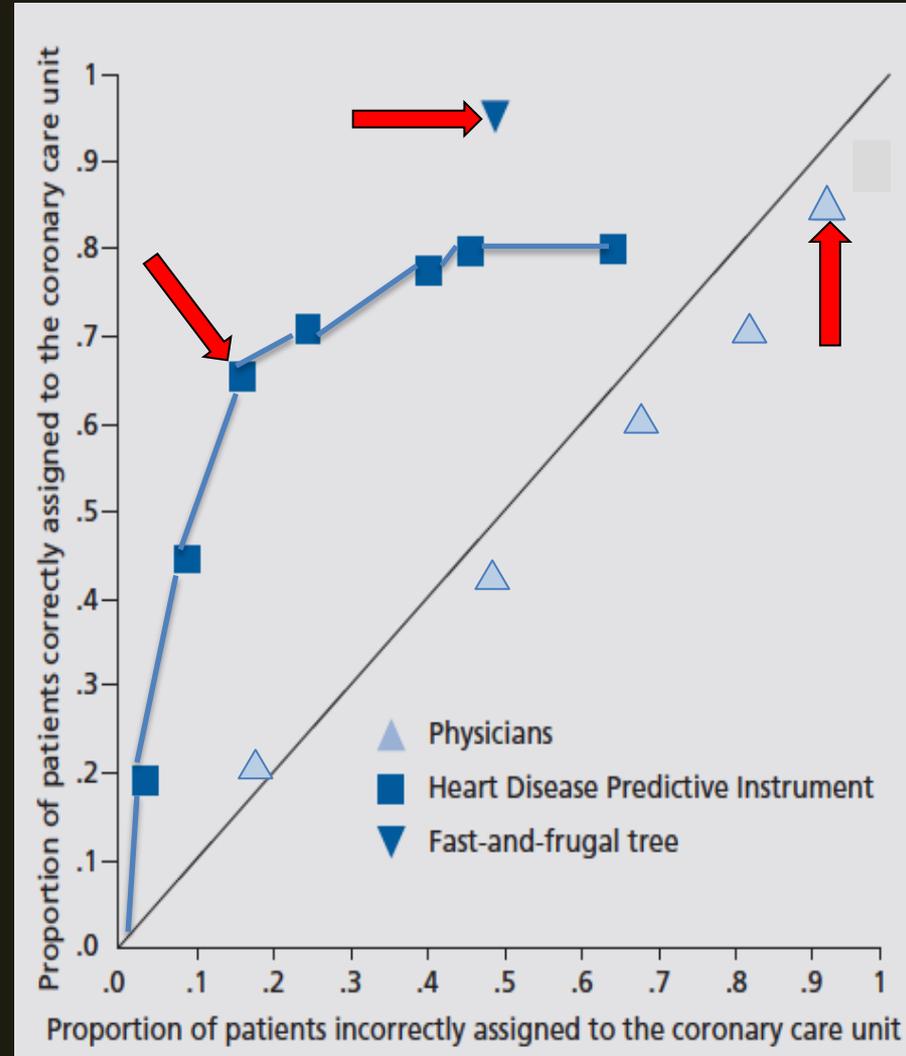
The START triage heuristic; mass casualty
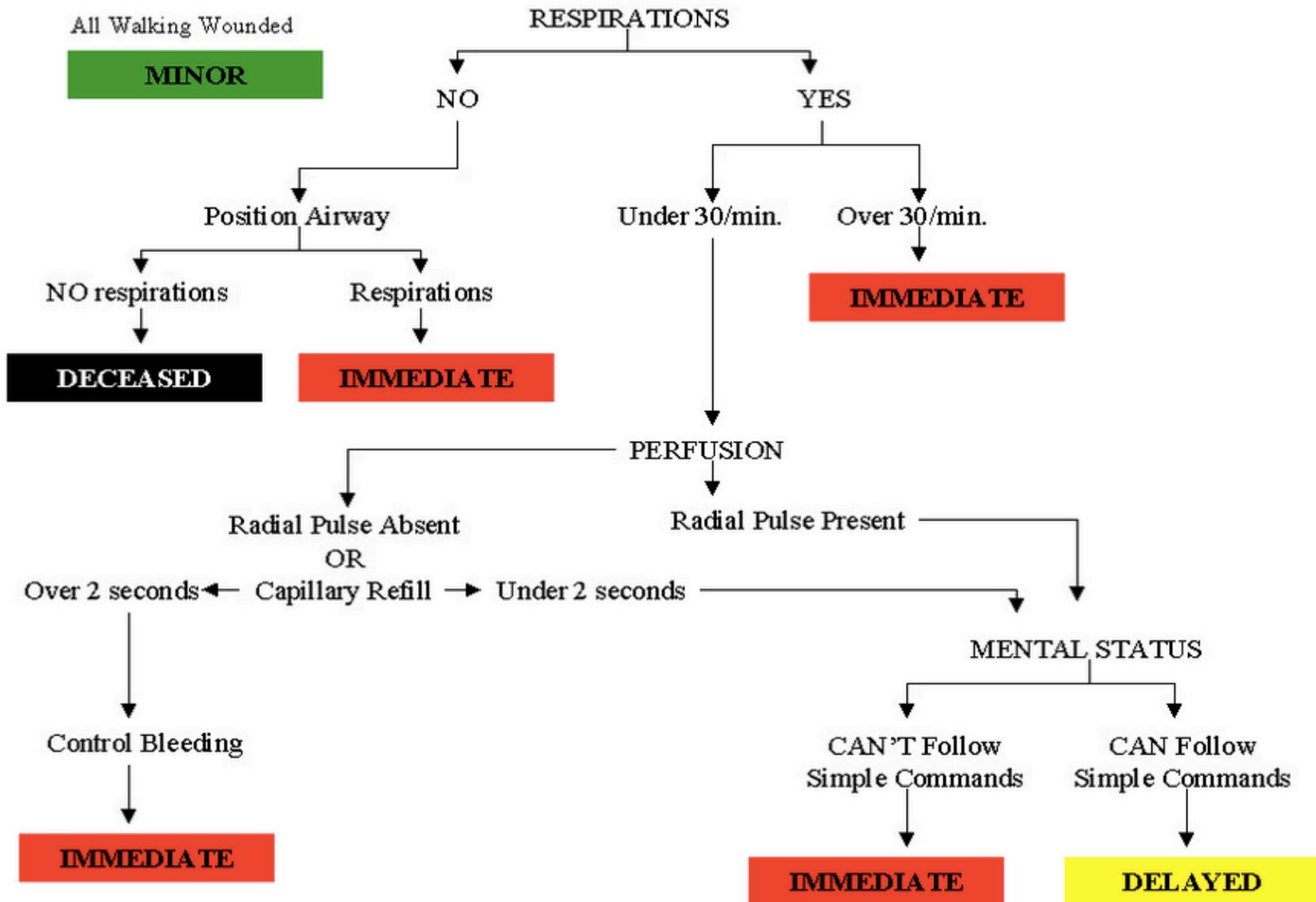
Poor decision making in medicine is unfortunately common

- Mammographic diagnoses of breast cancer are wrong up to 20% of the time

- 30% of patients with strokes receive incomplete or inappropriate care

- Diagnoses of AMI missed in 3.45% of 371,638 patients

- 5-14% of admission diagnoses in acute hospitals are erroneous in one review.

Pow RE, *2016*; Wilson M, *2014*; Miller CS, *2013*; A Gawande, The checklist manifesto *2010*;

Why do we see bad decisions in medicine?
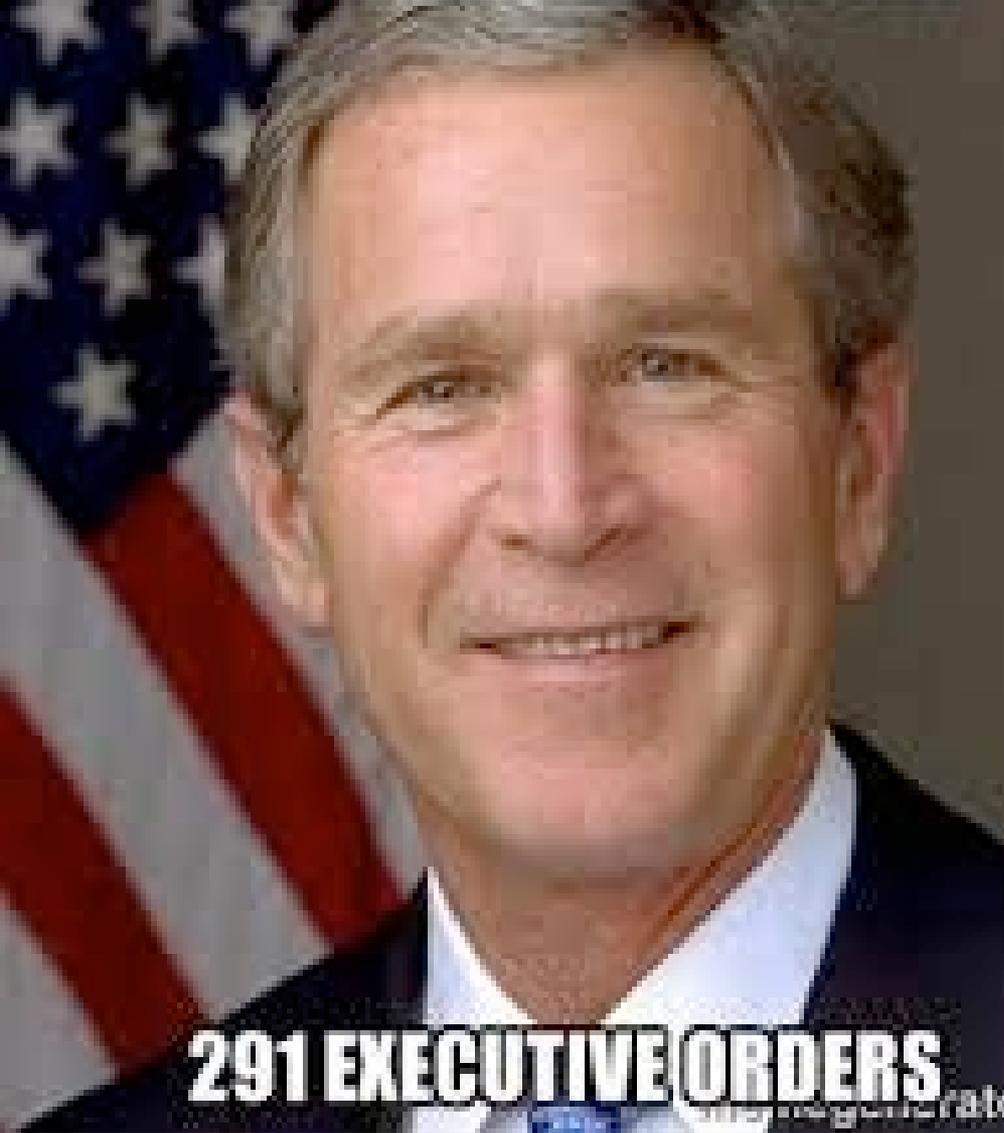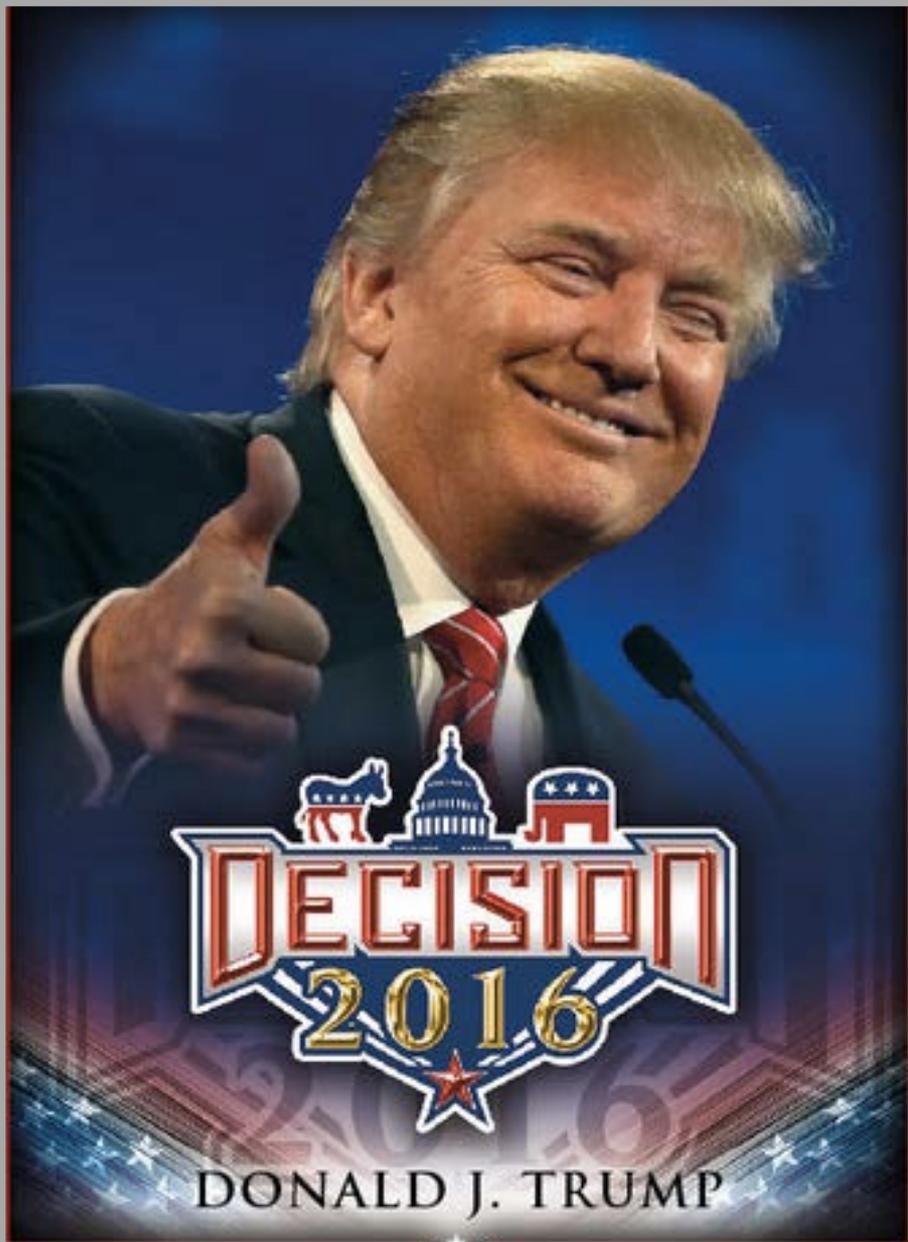
Why are so many bad decisions made?

May reflect our cave-man background, where life or death decisions had to be made quickly, on the basis of minimal information.

- Made without sufficient information
- Made too quickly, without proper reflection
- Made without appropriate consultation
- Bring in our own beliefs rather than being evidence-based

Comparison of Risk in Healthcare With Other Industries
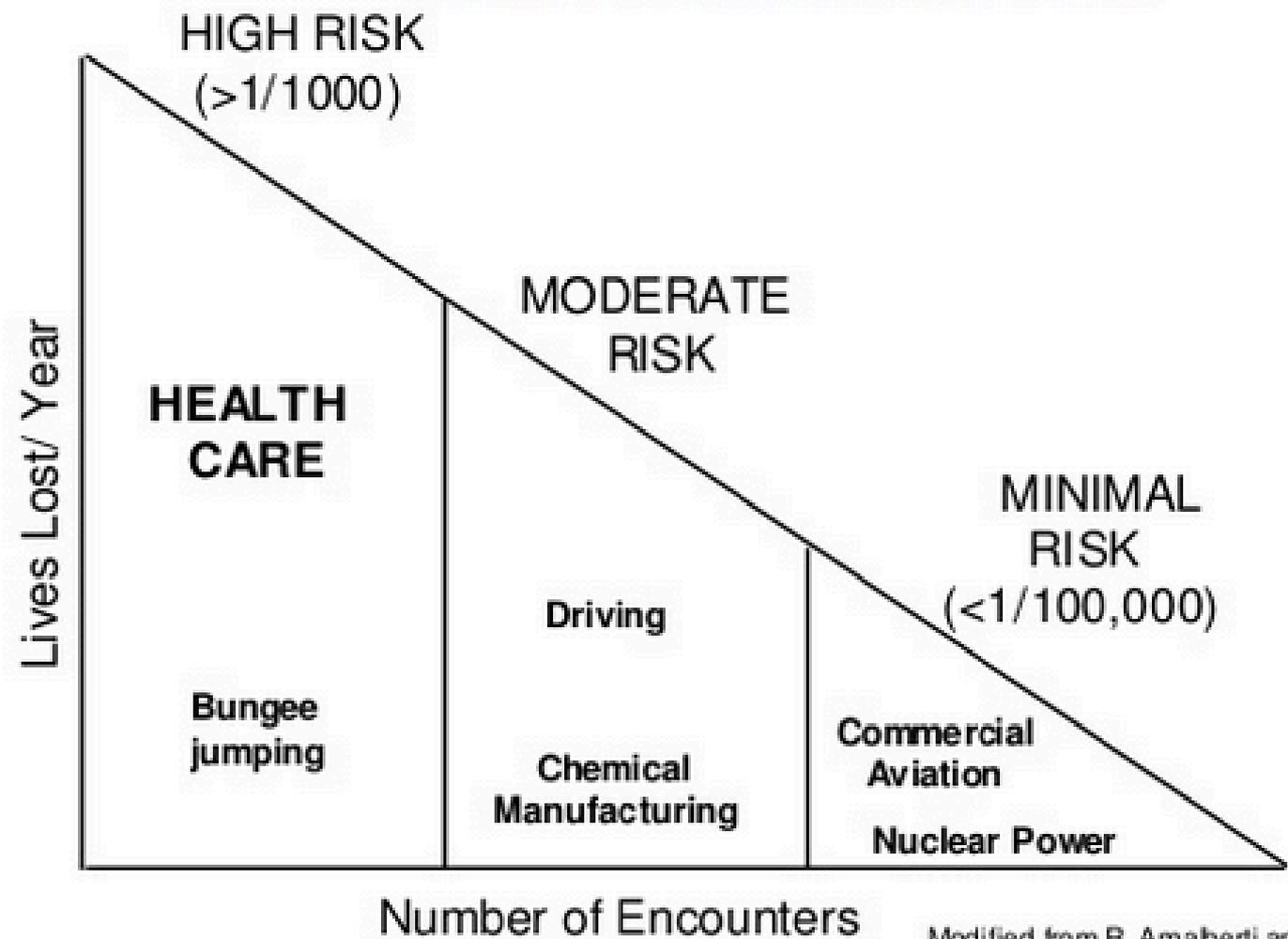
Modified from R. Amalberti and L. Leape
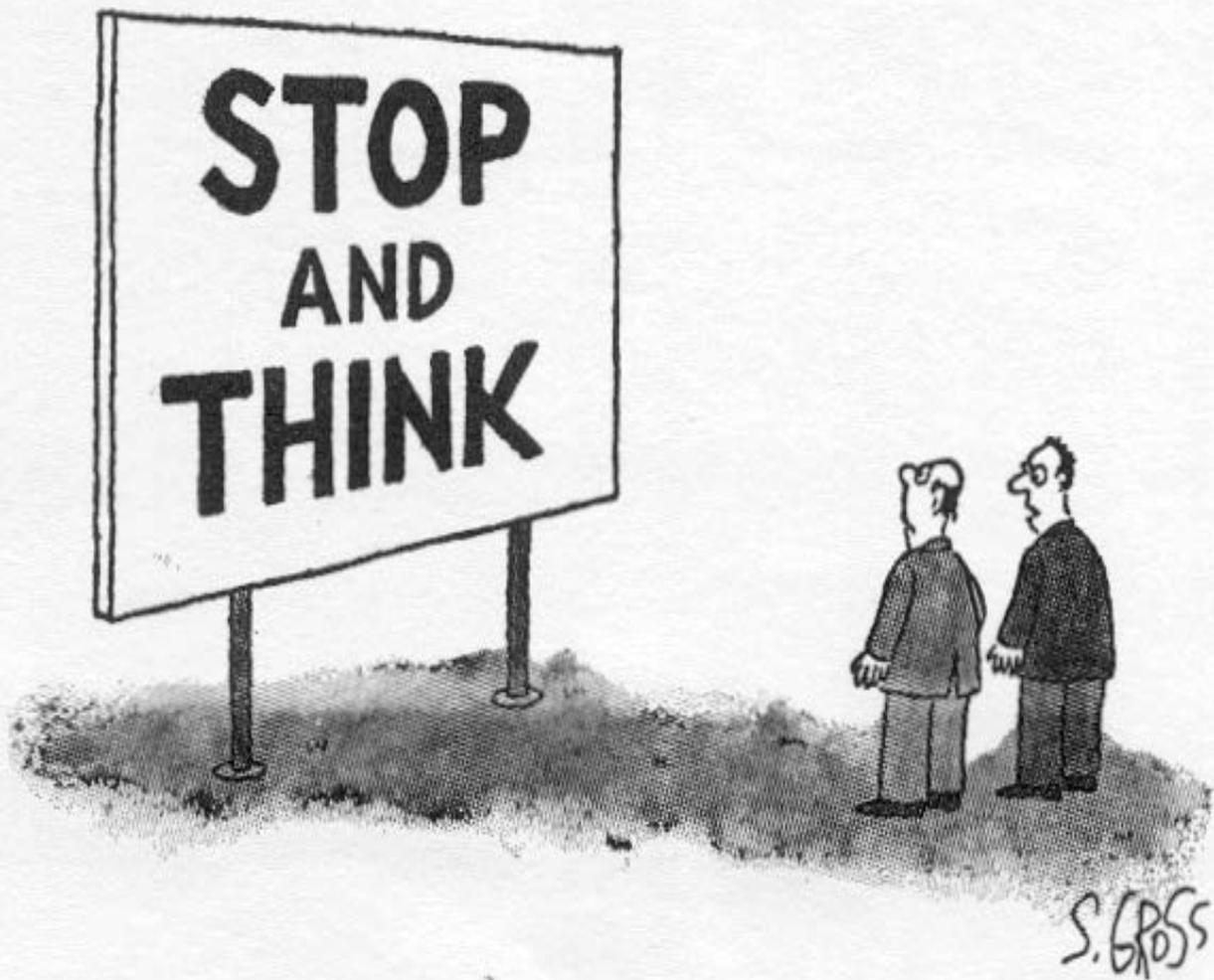
"It sort of makes you stop and think, doesn't it."

Common mistakes in decision making

- **Narrow framing:** failure to include ideas or information that bear on the decision

- **Conformation bias**: bias based on prior experience, or self-serving assumptions and information, including "cherry-picking" data

- **Emotional bias**: failing to remove yourself from your attachment to elements of the decision

- **Overconfidence:** acting without full evaluation; failure to anticipate future outcomes.

"Faults" in medical decision making, 1

- **Narrowed framing:** diagnostic possibilities not adequately explored
  - Prototype bias: you forget that common illnesses can have unusual presentations
  - Do you consider "rare" diagnoses as well as common ones?
  - Do you overuse stereotypes for diagnosis ?
  - Do you make "Attribution errors" – being influenced by patient characteristics not really relevant to the diagnosis (e.g. income status, gender).

Graber ML, 2005; Berner ES, 2008; Vick A, 2013.
Groopman & Hartzband have collected some useful cases with diagnostic errors:
   http://www.acphospitalist.org/archives/by-topic/mindful.htm

"Faults" in medical decision making, 2

- **Conformation bias**:
    - bias toward prior, easily-recalled experience
    - a more common /familiar diagnosis is picked above a more logical one
    - neglecting disease prevalence data
    - self-serving assumptions
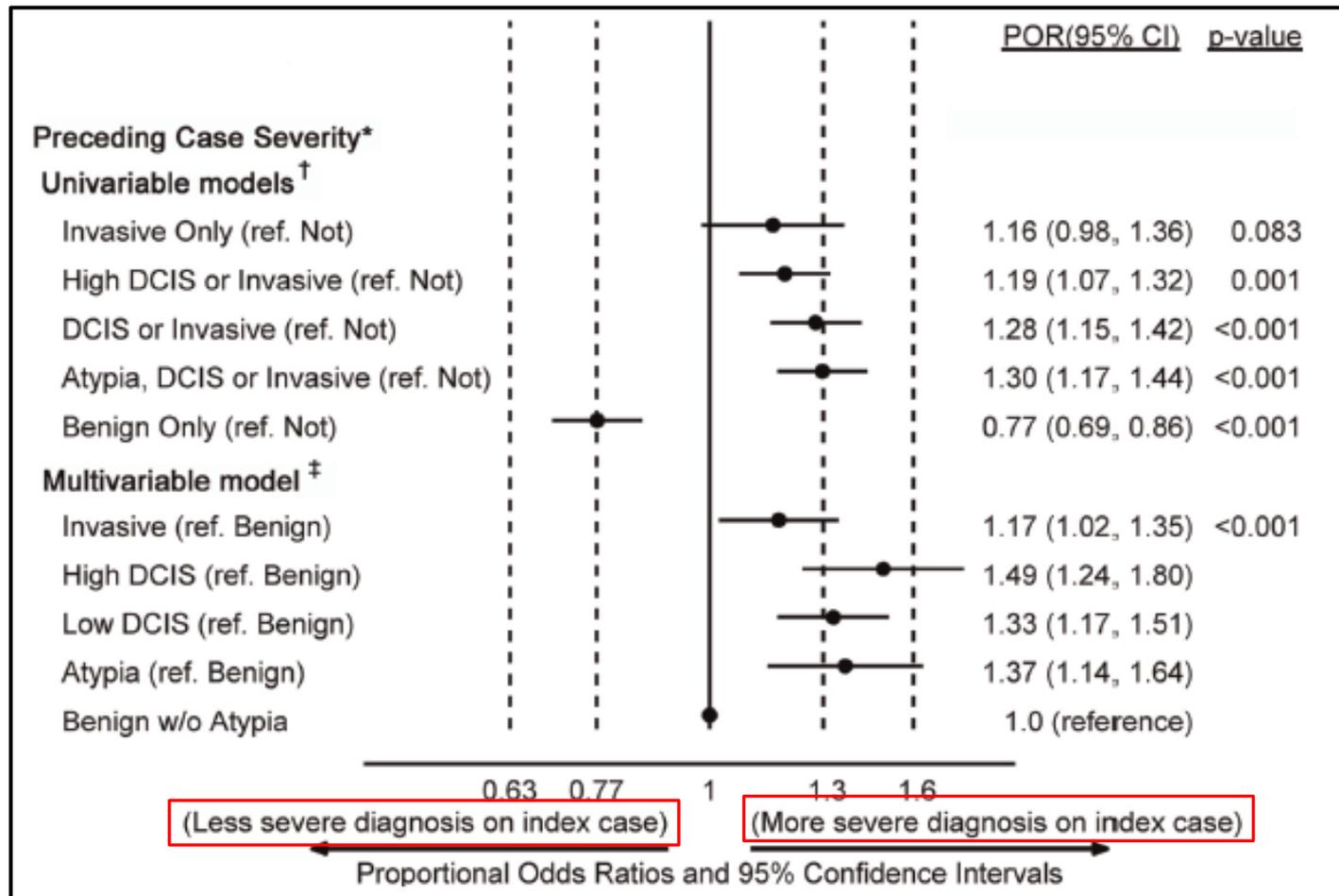   - cherry picking the data

- An example of conformation bias →

Graber ML, 2005; Berner ES, 2008; Vick A, 2013.
Groopman & Hartzband have collected some useful cases with diagnostic errors:
http://www.acphospitalist.org/archives/by-topic/mindful.htm

The Influence of Disease Severity of Preceding Clinical Cases on Pathologists' Medical Decision Making

Paul D. Frederick, MPH, MBA, Heidi D. Nelson, MD, MPH, Patricia A. Carney, PhD,
Tad T. Brunyé, Kimberly H. Allison, MD, Donald L. Weaver, MD,
Joann G. Elmore, MD, MPH

	POR(95% CI)	p-value
Preceding Case Severity*		
Univariable models†		
Invasive Only (ref. Not)	1.16 (0.98, 1.36)	0.083
High DCIS or Invasive (ref. Not)	1.19 (1.07, 1.32)	0.001
DCIS or Invasive (ref. Not)	1.28 (1.15, 1.42)	<0.001
Atypia, DCIS or Invasive (ref. Not)	1.30 (1.17, 1.44)	<0.001
Benign Only (ref. Not)	0.77 (0.69, 0.86)	<0.001
Multivariable model‡		
Invasive (ref. Benign)	1.17 (1.02, 1.35)	<0.001
High DCIS (ref. Benign)	1.49 (1.24, 1.80)	
Low DCIS (ref. Benign)	1.33 (1.17, 1.51)	
Atypia (ref. Benign)	1.37 (1.14, 1.64)	
Benign w/o Atypia	1.0 (reference)	

0.63   0.77   1   1.3   1.6

(Less severe diagnosis on index case)   (More severe diagnosis on index case)

Proportional Odds Ratios and 95% Confidence Intervals

"Faults" in medical decision making. 3

- **Emotional bias**:
  - Sticking to favorite diagnoses that should have been abandoned
  - You believe data supporting clinical practice guidelines don't apply to <u>your</u> patient
  - you fail to remove yourself from your attachment to the decision process
  - "Sunk costs" – the more you "invest" in a particular diagnosis, the less likely you will abandon it to consider other alternatives.

- **Overconfidence:** The tendency to believe we do more than what we actually do, or are correct more often than we really are.
  - As a physician, you claim a diagnosis without considering other diagnoses
  - Tendency toward action (e.g. Rx) vs inaction, despite data favoring inaction.
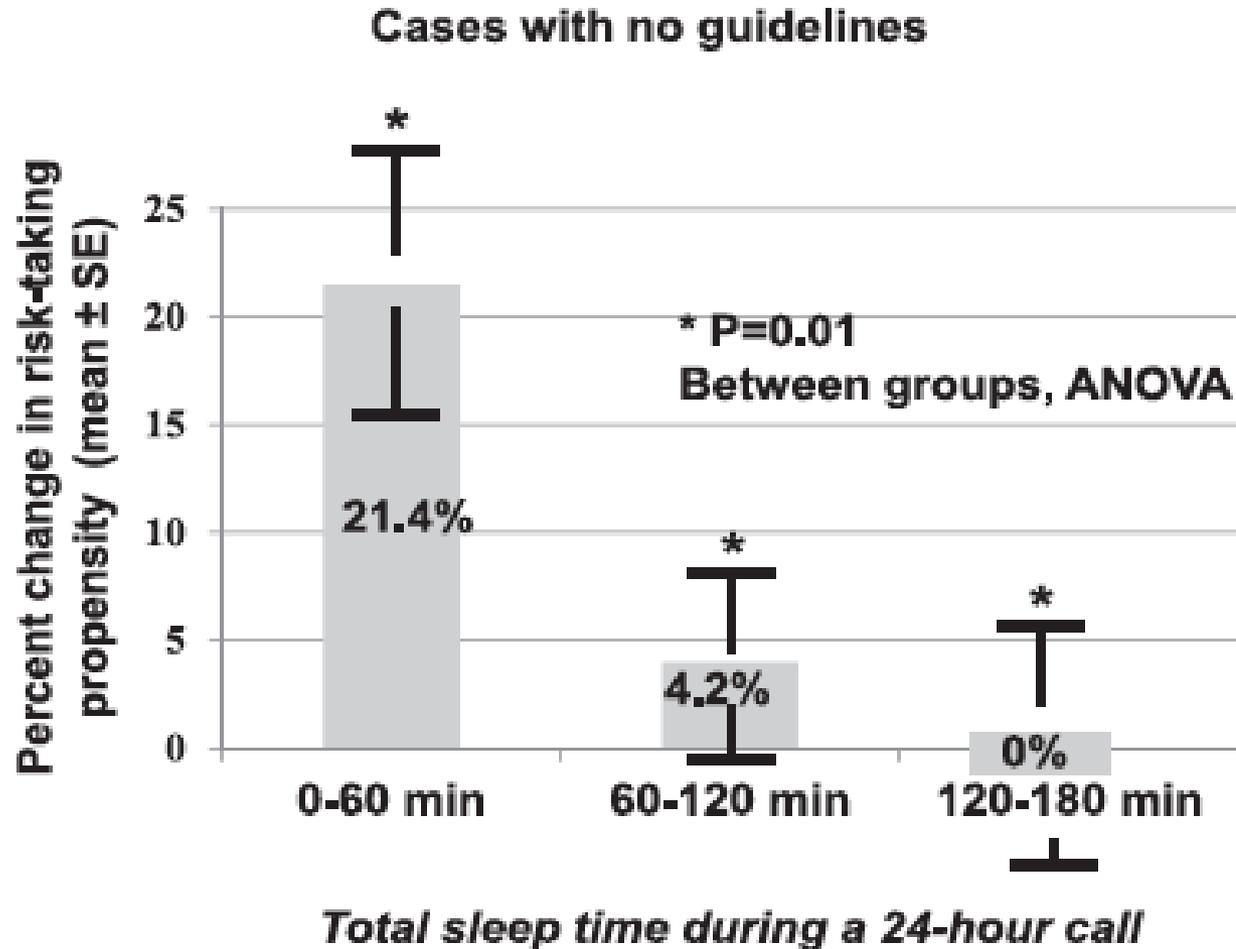
Casarett D, NEJM 2016; 374:1203, reiterates some of these faults

External situations affecting medical decision making

- **The health-care provider is working in a complex environment**
  - Almost invariably more than one person making the decision
    - other members of the patient's medical team, the patient & their friends and relatives
  - Often time constraints on decision making
  - The deciders may be fatigued
  - The decider may have unconscious bias

Medical Decisions of Pediatric Residents Turn Riskier after a 24-Hour Call with No Sleep

Cases with no guidelines

* P=0.01 Between groups, ANOVA

21.4% 4.2% 0%

Percent change in risk-taking propensity (mean ± SE)

0-60 min   60-120 min   120-180 min

Total sleep time during a 24-hour call

External situations affecting medical decision making

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Unconscious Bias

Slide courtesy of Prof Réne Salazar, UCSF

Unconscious Bias

- **Compelling body of scientific evidence shows unconscious bias has pervasive influences**
  - Daily interactions (microaggressions)
  - Hiring and promotion in the workplace
  - Evaluation
  - Scientific research:
    - 2/3 of all diseases affecting men and women are studied only in men
  - **Patient care**
    - Disparities in access, and quality of care

Unconscious Bias in Health Care

Medical student care recommendations for an <u>obese</u> vs non-obese pt

Obese patient: more negative stereotyping, less anticipated patient adherence (Persky, 2011)

<u>Racial</u> disparities in pain Rx of children with appendicitis in ERs

Black children with appendicitis less likely to receive opioid medication than white children (12 vs. 34%) (Goyal 2015)

Unconscious race and <u>social class</u> bias among acute care doctors

Time before patients were seen was longer with those from lower social class; male doctors were worse than female (Haider *et al.,* 2015).

Effect of patients' <u>sex</u> on doctors' recommendations for total knee arthroplasty (TKA)

Of standardized subjects, 42% of men were recommended for TKA versus 8% of women (Borkhoff, 2008)

The 2013 general audience book that fully explains the IAT

BLIND SPOT

Project Implicit®

PROJECT IMPLICIT SOCIAL ATTITUDES

Log in or register to find out your implicit associations about race, gender, sexual orientation, and other topics!

E-mail Address   **LOGIN**   **REGISTER**

Or, continue as a guest by selecting from our available language/nation demonstration sites:

United States (English)   **GO!**

PROJECT IMPLICIT MENTAL HEALTH

Find out your implicit associations about self-esteem, anxiety, alcohol, and other topics!   **GO!**

PROJECT IMPLICIT FEATURED TASK

Measure your implicit associations with U.S. presidential candidates

GO!

https://implicit.harvard.edu/implicit/

How can one improve medical decision making? Be aware of potential biases

- **Consider unconscious bias** & do some Implicit Association Tests.
  - Conscious bias is easier to correct than the latter
  - Use "individuating" - focus away from patient characteristics that stimulate bias but are irrelevant for diagnosis.
- **Avoid narrow framing** – look beyond the initial Dx; if your first diagnosis is based on heuristic-intuitive reasoning, follow with a more analytical approach asap.
- **Conformation bias** is hard to avoid, but asking others to review the patient helps. Don't cherry-pick data – that's easy to avoid.
- **If inner feelings suggest emotional bias** (e.g. a favorite patient), call in others in the team

But improving medical decisions is not easy!

Lebrecht S, 2009; Chapman KR, 2001; Todd AR, 2011; Drwecki BB, 2011

Will the
Art of Medical Decision Making
persist in the era of Big Data,
Machine Learning, and
Artificial Intelligence

How these impact medical decision making

- **Big Data:**
  - Huge amounts of raw medical data
    - available via e.g. Google, PubMed, medical texts & patients' records
  - Requires computer programs & IT staff

- **Machine Learning** - gives computers the ability to learn without being explicitly programmed" (Arthur Samuel, 1959)
  - *e.g. the spam filter on your computer*

- **Artificial Intelligence (AI):** high-end machine learning

- **Can Big Data plus AI** → provide Clinical Decision Support Services (CDSS) **OR** replace human decision making?

Big Data, Machine Learning & Artificial Intelligence (AI) are already involved in medical decision making

- ***My Google** search on the following variables:*
  - Find Diagnosis:
  - visited Thailand
  - rash
  - fever
  - headache,
  - thrombocytopenia

- *Google* **Result 1:**
  - Diagnosing the Tropical Tropical Traveler. Free medical information
- *G**oogle* **Result 2:**
  - Dengue Fever | Doctor | Patient
- ***Bing** **Search:***
  - 3rd result – Dengue Fever

A Tool to Reduce Inappropriate Medications (TRIM)
A Clinical Decision Support System to improve medication prescribing
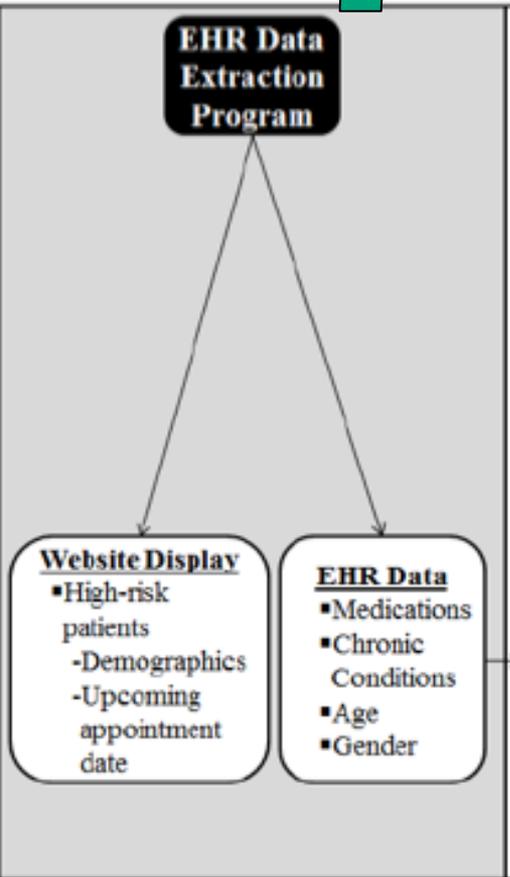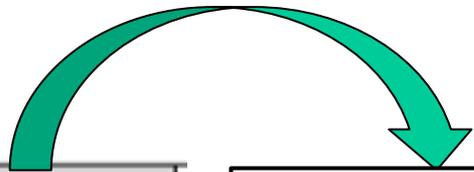
MEDICATION RECONCILIATION

The CPRS medication list and the patient's medication list **do not match.**

DISCREPANCY	MEDICATIONS	
	Prescribed/CPRS	Home
Dose and/or schedule is different:	METFORMIN HCL 500MG 24HR SA TAB. TAKE ONE TABLET BY MOUTH ONCE DAILY FOR DIABETES	METFORMIN HCL 500MG 24HR SA TAB. TAKE ONE TABLET BY MOUTH ONCE WEEKLY FOR DIABETES
Patient taking the following medication(s) NOT on active medication list in CPRS:	NAPROXEN 220MG TAB. TAKE ONE TABLET BY MOUTH ONCE DAILY AS NEEDED FOR ARTHRITIS	
Patient NOT taking the following medication(s) listed in CPRS:	TEMAZEPAM 15MG CAP. TAKE ONE CAPSULE BY MOUTH AT BEDTIME AS NEEDED FOR SLEEP	
Your patient was unable to name the dose and/or schedule of the following medications:	FISH OIL CAP. TAKE ONE TABLET ONCE DAILY	

Niehoff KM, *et al.* Pharmacotherapy. 2016 doi: 10.1002/phar.1751

FindZebra: A search engine for rare diseases

- 33,144 datasets from curated medical sources re rare diseases made up the database for the search engine.
- 56 queries were chosen for testing, all rare diseases, with query text extracted exactly from clinical findings in the original cases.
- The 56 queries were fed to FindZebra & other search engines

Search Engine Used	Correct Result in	
	Top 10 Findings (%)	Top 20 Findings (%)
FindZebra	63	68
Google Search	29	32
Google Custom	30	38
Google Restricted	11	11
PubMed	13	16

IBM Watson Health's Deep QA

•pitch to doctors: will assist with Dx

•pitch to administrators: will save $$

(= commercial emphasis)

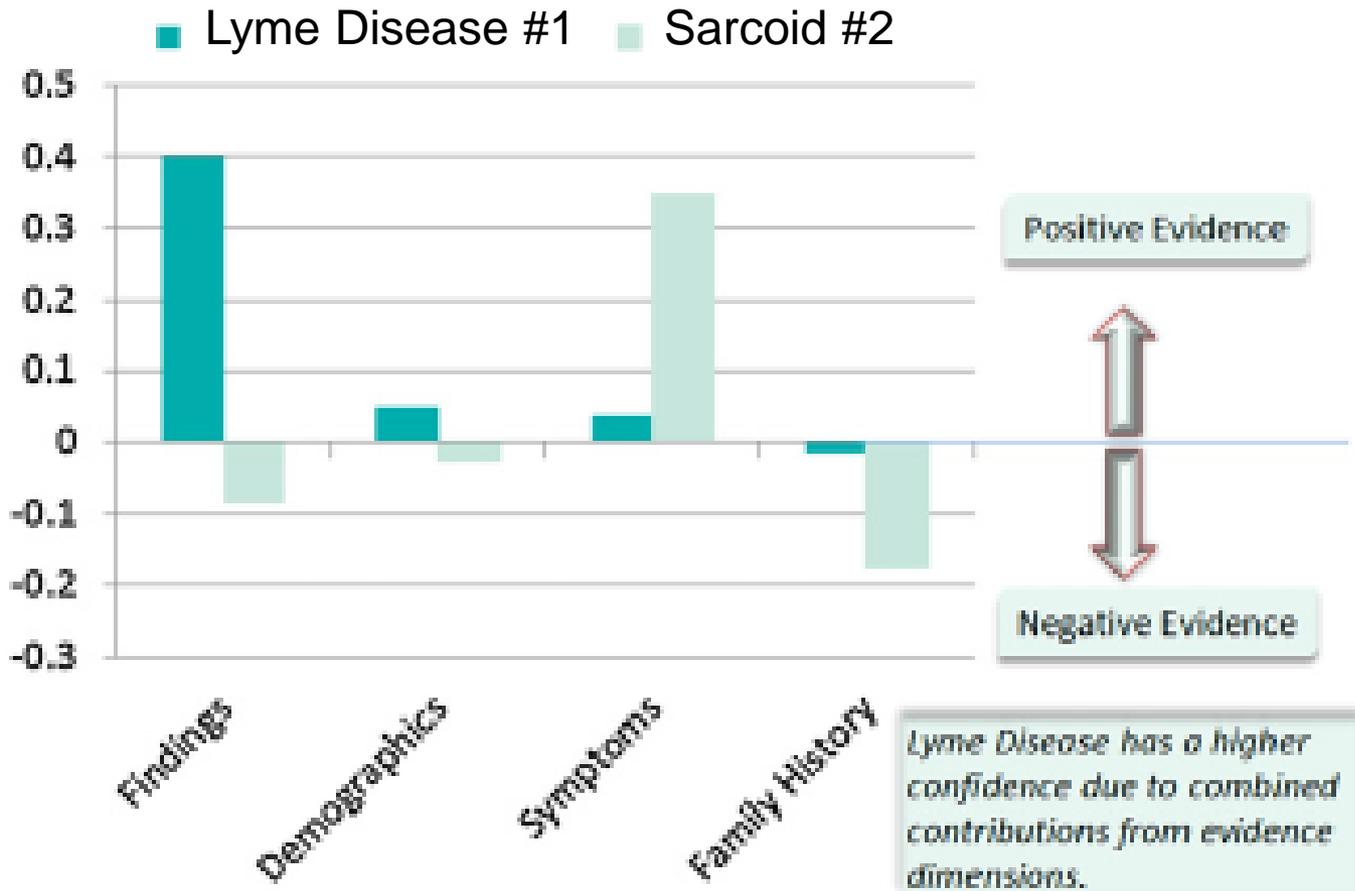**How does Watson Health work?**
- **Takes a question, searches and retrieves evidence**
- **Ranks hypotheses & diagnoses with levels of probability**
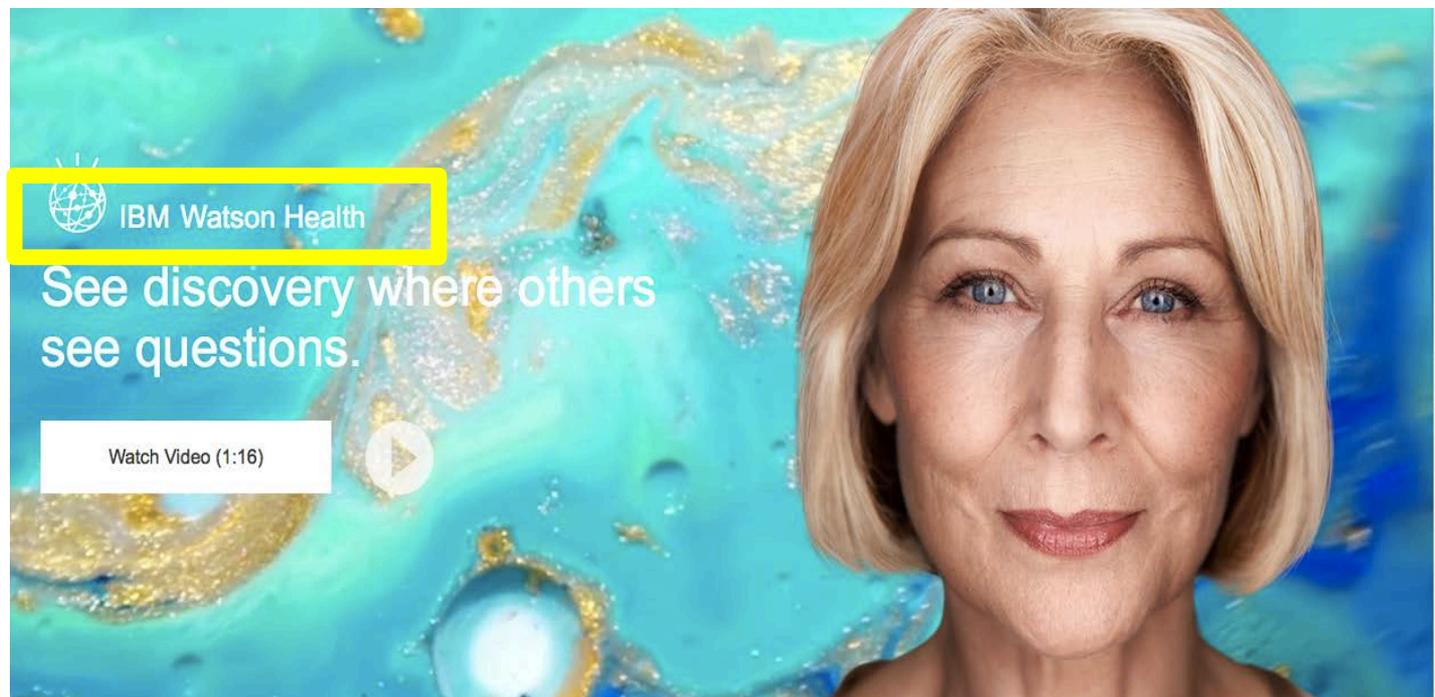
Some examples of Watson in action

Q: **What are diseases, causes of uveitis with circular rash, fever, headache, arthritis and family history of arthritis for patient who lives in Connecticut?**
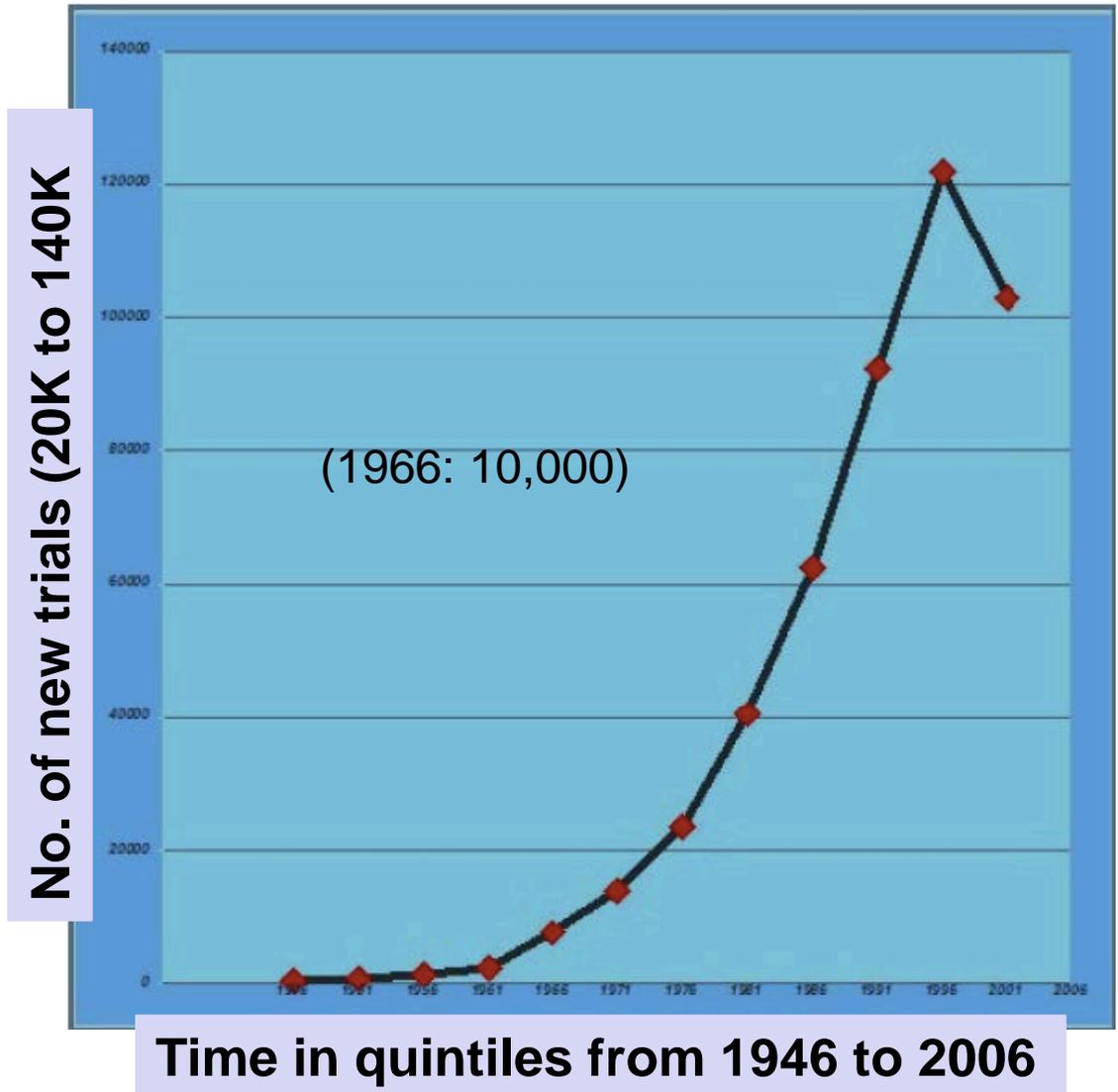
Jeremy Howard, CEO and Founder

For some reason, medicine was being treated as a second-class citizen in benefiting from the opportunities of deep learning. I founded Enlitic to fix this problem.

Howard's mantra is that "Data-Driven Medicine" with "Deep learning" technology can save lives by helping detect curable diseases early

Some obstacles to Big Data and Machine Learning

- Adding 4000 new clinical trials / year

- >500 petabytes of current medical data
  - 25,000 Pb by 2020

- **PubMed:**
  - 2015: 1,240,414 new papers
  - 1966: 180,000

Gluud C, 2007

Chart: No. of new trials (20K to 140K), with annotation (1966: 10,000). Time in quintiles from 1946 to 2006.
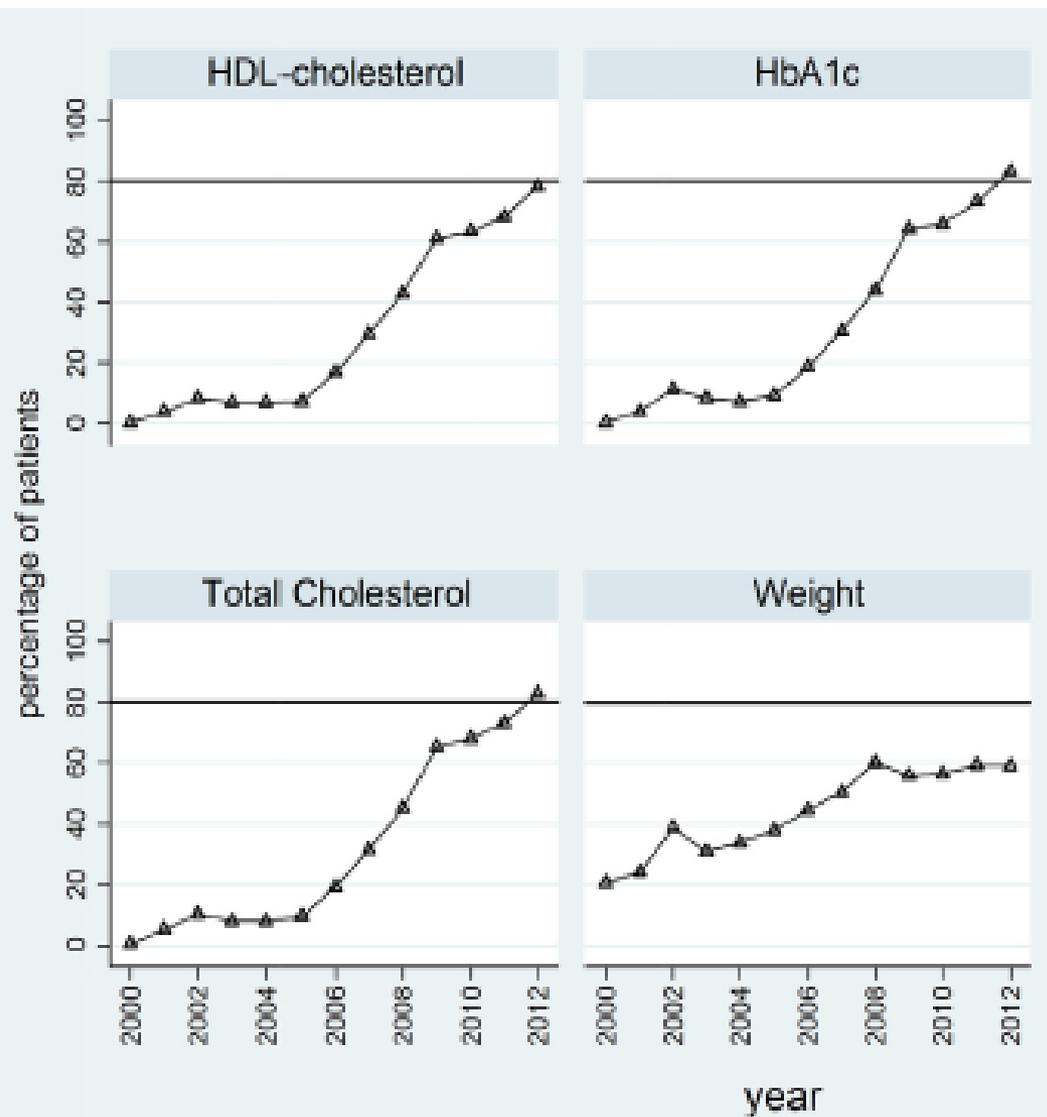
Further caveats about Big Data & Machine Learning

- Adding new info to the database (Gluud & Nikolova, 2007; Foster *et al.,* 2014)

- Repairing common software malfunctions (Wright *et al., 2016*)

- Software developed in one place may not be useable in another setting (Foster *et al.,* 2014)

- Can the data in the electronic medical record (EMR) be good enough to make it useful?

- A 2014 review of 28 Clinical Decision Support Systems (CDSS) integrated with EMRs indicated that none affected mortality; 9 had a small but significant effect on prevention of morbidity (RR 0.82) (Moja *et al.,* 2014)

- Can the CDSSs be brought to the bedside?

- Where is the money coming from for all this IT?

Getting good data from the EMR may not be easy

Percentages of the indicated data from type 2 diabetes patients found in their GP's electronic medical record

Data are from 2000 to 2012.

Staff M, Roberts C, March L. Primary Care Diabetes, 2016. http://dx.doi.org/10.1016/j.pcd.2016.02.002

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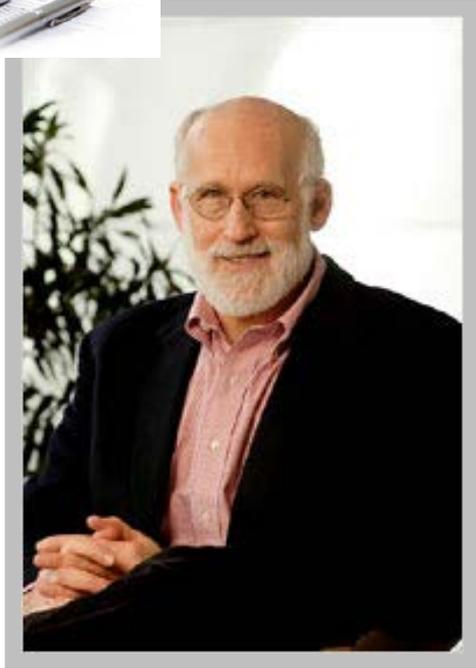
"…algorithms discourage physicians from thinking independently and creatively.'

"There is great expectation BUT scant evidence to date that computer programs are superior to experienced clinicians in accurate diagnosis."
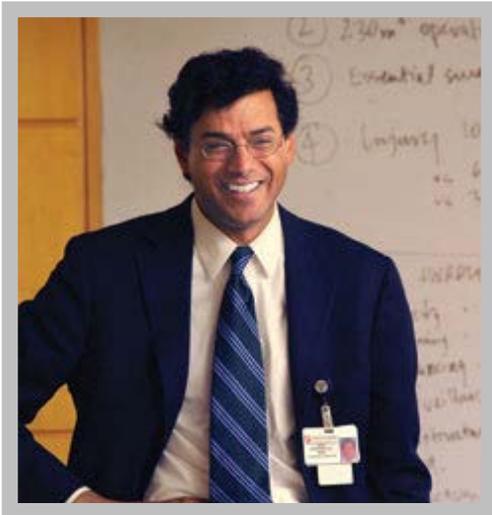
"Until recently, we built medicine around a culture … that said what you were good at was being daring, courageous, independent and self-sufficient. Autonomy was our highest value. That's no longer possible: specialization requires teamwork."

No quotes, but clearly supports use of "Big Data" to add to routine decision making

My predictions for medical decision making

- Improved accuracy of electronic medical records will be needed first

- Better formats of EMRs to facilitate collection of patient data in a form that can be analyzed

- "Clinical Decision Support Systems" (CDSS) may soon become common in specific areas of practice; preventive measures > diagnostics

- Use of big data, machine learning and artificial intelligence for general diagnostic use is some time away