2030: 20% doctor included?

an exercise in technology speculation & musings

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10% to 20% of cases:
delayed, missed, and incorrect diagnosis

graber, et al., jama (2012)

40,000+ patients in u.s. icus
may die with a misdiagnosis annually

winters, et al., bmj quality & safety (2012)

50% of MDs are below average (median)

math

human doctors

cognitive limitations

cognitive biases

- http://www.jround.co.uk/error/reading/crosskerry1.pdf
- http://www.nejm.org/doi/full/10.1056/NEJMp1303712
- http://www.ncbi.nlm.nih.gov/pubmed/21392683
- http://www.ncbi.nlm.nih.gov/pubmed/16009864
- http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2219858/
- http://qualitysafety.bmj.com/content/22/12/1044.abstract
- http://www.sciencedaily.com/articles/l/list_of_cognitive_biases.htm
- http://evimedgroup.blogspot.com/2010/10/cognitive-biases-in-medicine.html

a study of one hundred cases of diagnostic error involving internists found…

graber, et al., jama internal medicine (2005)

…system-related factors contributed to the diagnostic error in 65% of the cases and cognitive factors in 74%...

graber, et al., jama internal medicine (2005)

…premature closure was
the single most common cause

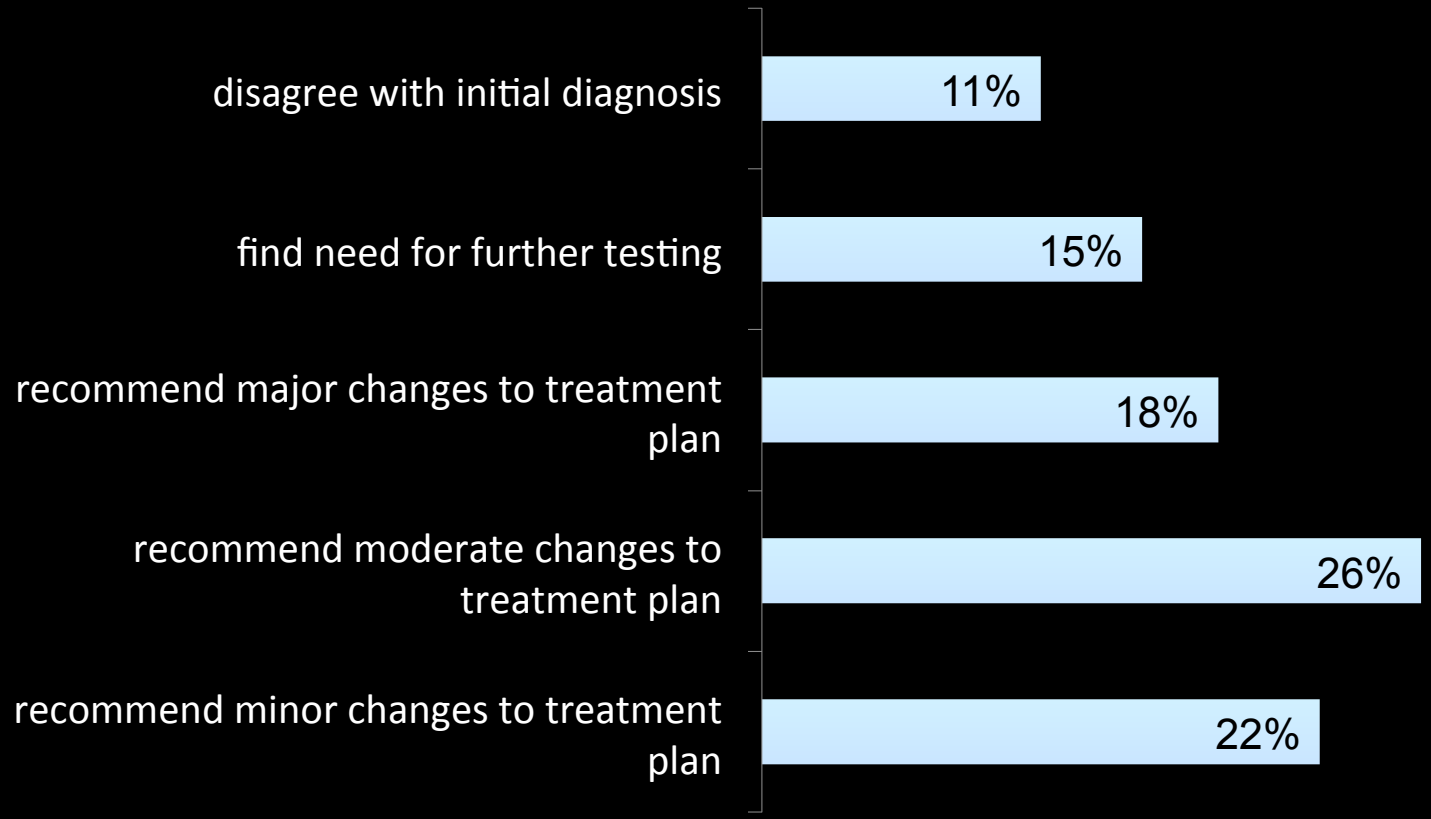
graber, et al., jama internal medicine (2005)

in many records of patients with a high-risk diagnosis, high-information clinical findings were present before the diagnosis was established

feldman, et al., jamia (2012)

the value of second opinions

cleveland clinic doctors' review of initial diagnosis



http://www.businessinsurance.com/article/20111204/NEWS05/312049987?tags=|74|305|339|342

the American College of Cardiology and the American Heart Association made 7,196 recommendations leading to 53 practice guidelines on 22 topics…

…48% have level C evidence (the worst kind)…

…11% have level A evidence (the best kind)…

…and only 19% of recommendations in class I guidelines had level A evidence

tricoci, et al., jama (2009)

surgeons were given detailed diagnoses & asked if patients should get surgery …

half said yes … the other half said no …

… when asked again two years later, 40% of the docs gave a different answer

eddy, jama (1990)

fifty-eight experts' estimates of the chance of an outcome of an important procedure

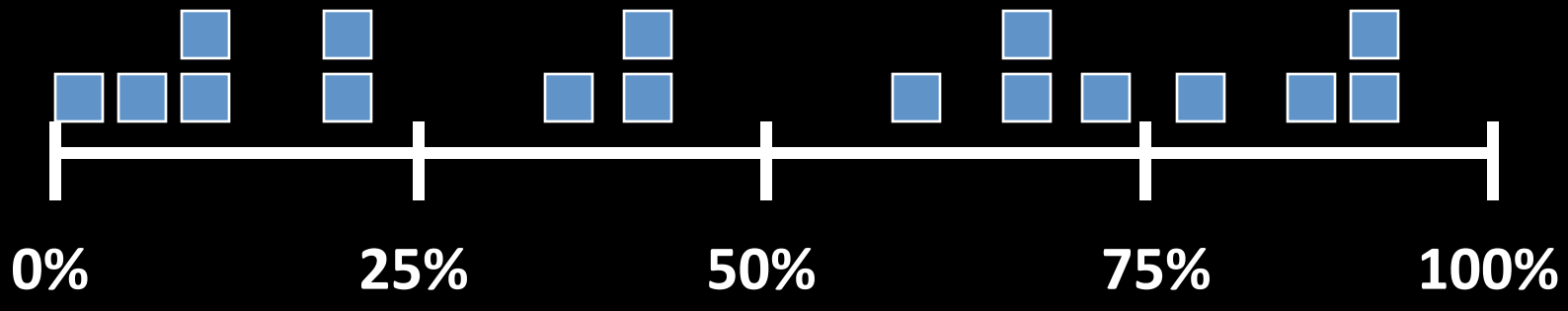
0% 0.2% 0.5% 1% 1% 1% 1.5% 1.5% 2% 3% 3% 4%
5% 5% 5% 5% 5% 5% 5% 6% 6% 6% 8% 10% 10%
10% 10% 13% 13% 15% 15% 18% 20% 20% 20%
25% 25% 25% 30% 30% 40% 50% 50% 50% 62%
70% 73% 75 75% 75% 75% 80% 80% 80% 80%
80% 80% 100%

what does a consensus of a group whose perceptions might vary from 0% to 100% even mean?

eddy, jama (1990)

wide ranges of uncertainty

seventeen experts' estimates of
the effect of screening on colon cancer deaths



= one expert's response

eddy, jama (1990)

conventional wisdom and the “tradition of medicine”

should fever be reduced in critically ill patients?

“there were seven deaths in people getting standard treatment and only one in those allowed to have fever”

“the team felt compelled to call a halt, feeling it would be unethical to allow any more patients to get standard treatment”

matthews, et al., new scientist (2010)

there is good reason
to challenge the assumption
that every individual practitioner's decision
is necessarily correct

eddy, jama (1990)

40-50% of the recommendations made in guidelines are based on expert opinion, case studies, or standards of care rather than on more systematic trials and studies

chauhan, et al., american journal of obstetrics and gynecology (2006); institute of medicine (2008); tricoci, et al., jama (2009)

the current guideline suggesting β-blockers before serious surgery is pretty effective…

…at increasing risk of mortality by 27%

bouri, et al., heart (2013)

medical wisdom upended…

committee examined the idea of target LDL levels when 2 doctors asked for efficacy evidence…

kolata, new york times (2013)

for most study designs and settings,
it is more likely for a research claim
to be false than true

ioannidis, plos med (2005)

existing clinical practice guidelines make conflicting recommendations…

for a hypothetical 79-year-old woman with osteoporosis, osteoarthritis, type 2 diabetes, hypertension, and chronic obstructive pulmonary disease…

…if she had peripheral neuropathy, guidelines for osteoporosis would recommend that she perform weight-bearing exercise, while guidelines for diabetes would recommend that she avoid such exercise

boyd, et al., jama (2005)

medical care often is guided insufficiently by evidence, with americans receiving only about half of the preventive, acute, and chronic care recommended by current research and evidence-based guidelines

mcglynn, et al., nejm (2003)

entrepreneurs will ask
the naïve questions that uncover
hidden assumptions…

…and move us to
the grey zone of “speculations”

..do we need humans out of the loop?

…or a different role?

in the future,
patients will have the data & analysis to
become the CEO of your own health

peter diamandis

80% of what MDs do can be replaced (with better care than the median MD)…

…but not every MD function will be replaced

the “human” element of care can be provided by the most “humane” humans

(and MDs can be humane)

machines are better at integrative medicine…

…across “all symptoms”, demeanor, patient history, phone activity, 1000s of data points, genomics, population management guidelines, …

Lifecom CHAMP in acute care

I …distributed care with medical assistants were 91% accurate
without labs, imaging, or exams

II …“safe triage” with 75% physician bypass rate for acute care encounters

isabel II

matched expert diagnoses
91-95% of the time

graber, et al., journal of general internal medicine (2008)

new computer models analyze microscopic breast cancer images…

…and predict patient survival better than today's pathologists

beck, et al., sci transl med (2011)

dr. algorithm

v0

the transition will start with
“toddler MDs” and digital first-aid kits

Cellscope: personal mobile ENT+

Eyenetra: auto-optometrist

Alivecor: your phone as EKG+

Quanttus: medical metrics (HR, BP, SV, CO, RR, T, …) in a consumer device

Ginger.io: *real* mental health

Adamant: diagnosis by breath

Kyron: practice-based evidence

Lumiata: graph of medicine filling today's care gaps

Healthtap, Crowdmed: crowdsourced health answers

Jawbone, Misfit: wellness wearables

don’t get an ecg just when you can make it to the hospital…

…take your own ecg anytime, anywhere, for less than $1…

…and know you have heart disease before you have an attack!

AliveCor

*a khosla ventures investment


AliveECG™
Version 1.4.8
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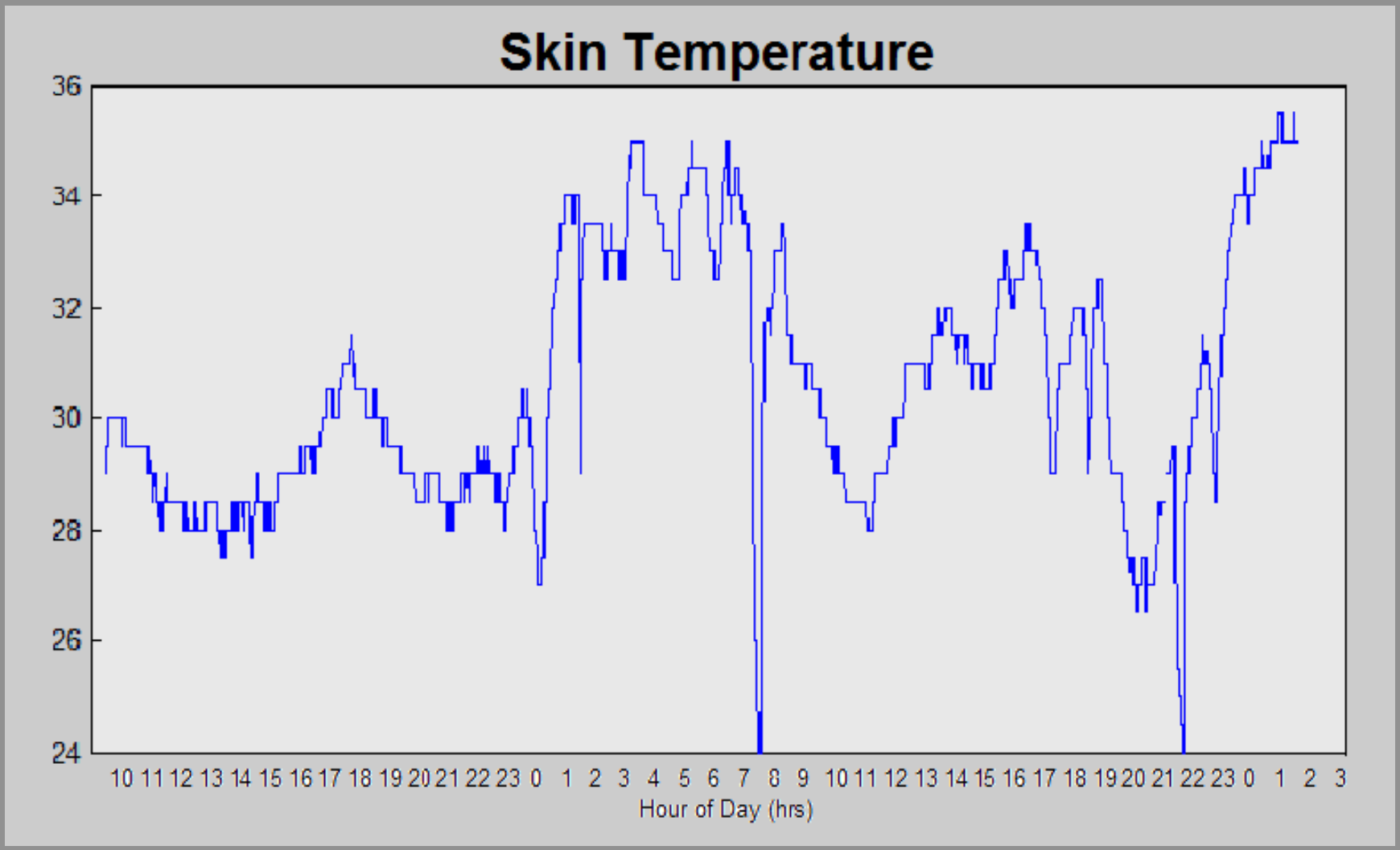

Quanttus

*a khosla ventures investment

use your phone to closely monitor behavioral patterns…

…and get more reliable mental health diagnoses than a trained psychiatrist could provide

…software as a drug

Ginger.io

*a khosla ventures investment


calling
texting
location
accelerometer
ALL DATA IS COLLECTED PASSIVELY
(* AFTER OPT-IN)

google mapped the knowledge graph…
facebook mapped the social graph…

…now we have the medical graph…
…discovering missed diagnoses and filling care gaps

…determine how symptoms, diseases
and patient information are connected

Lumiata

*a khosla ventures investment

data-driven findings will uncover patterns in clinical data…

…and algorithmically create new clinical guidelines…

…using practice-based evidence

…use data-mining to avoid adverse drug reactions and do post-study studies

Kyron

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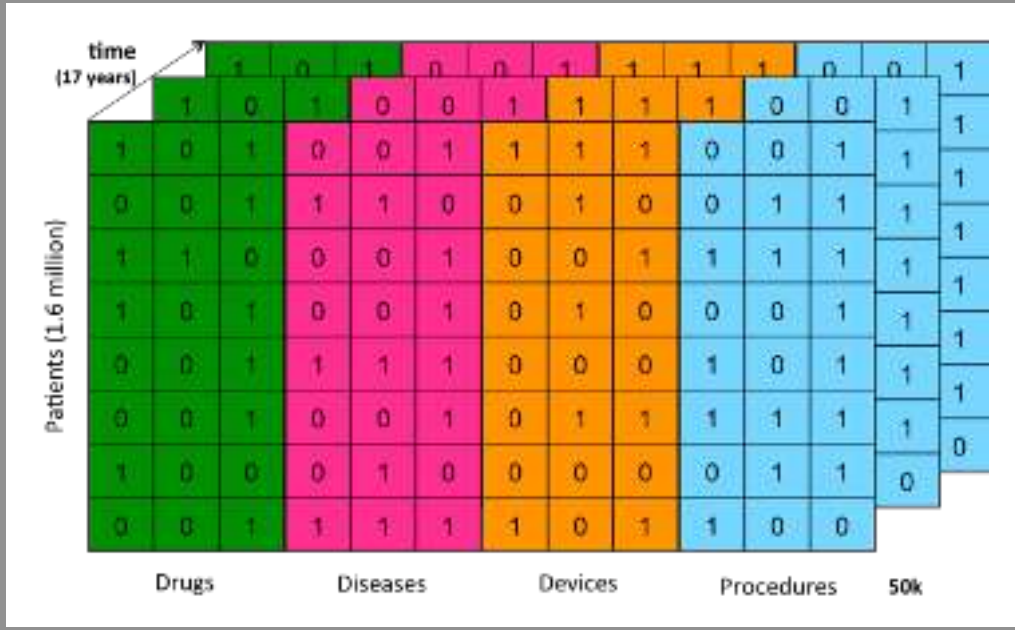

time
(17 years)
Patients (1.6 million)
Drugs
Diseases
Devices
Procedures
50k

track your life…

…all from your wrist

Jawbone/Misfit

*khosla ventures investments

keep people out of the doctor's office…

…with point innovations in cardiology, dermatology, optometry, psychiatry, internal medicine, …

innocuous point innovations…

…will evolve into a wave and explode into a tsunami

dr. algorithm

v0 – 2015
v1 – 2017
v2 – 2019
v3 – 2021
v4 – 2023
v5 – 2025
v6 – 2027
v7 – 2029
…

2-3 years per generation

we'll start with clumsy point innovations like alivecor, cellscope, adamant, ginger.io, neurotrek, consumer physics, jawbone, misfit, …

…"insighted" by machine learning…

…leading us to discover things we never knew were right in front of us

the best MDs will train systems
over 10-20 years…

…systems will symbiotically provide
“bionic assist” and “AMPLIFY” MDs

dr. house+++ will be
the trainer for dr. algorithm

…no manners required!

…but manners learned!

most [patients] preferred
receiving their discharge information from
the [computer] agent
compared to their doctors or nurses
in the hospital

bickmore, et al., interacting with computers (2010)

findings thanks to data

using statins for in-hospital stroke patients reduced the death rate by 40%!

findings thanks to data: diabetes risk factors

depression

taking statins

staying up late at night

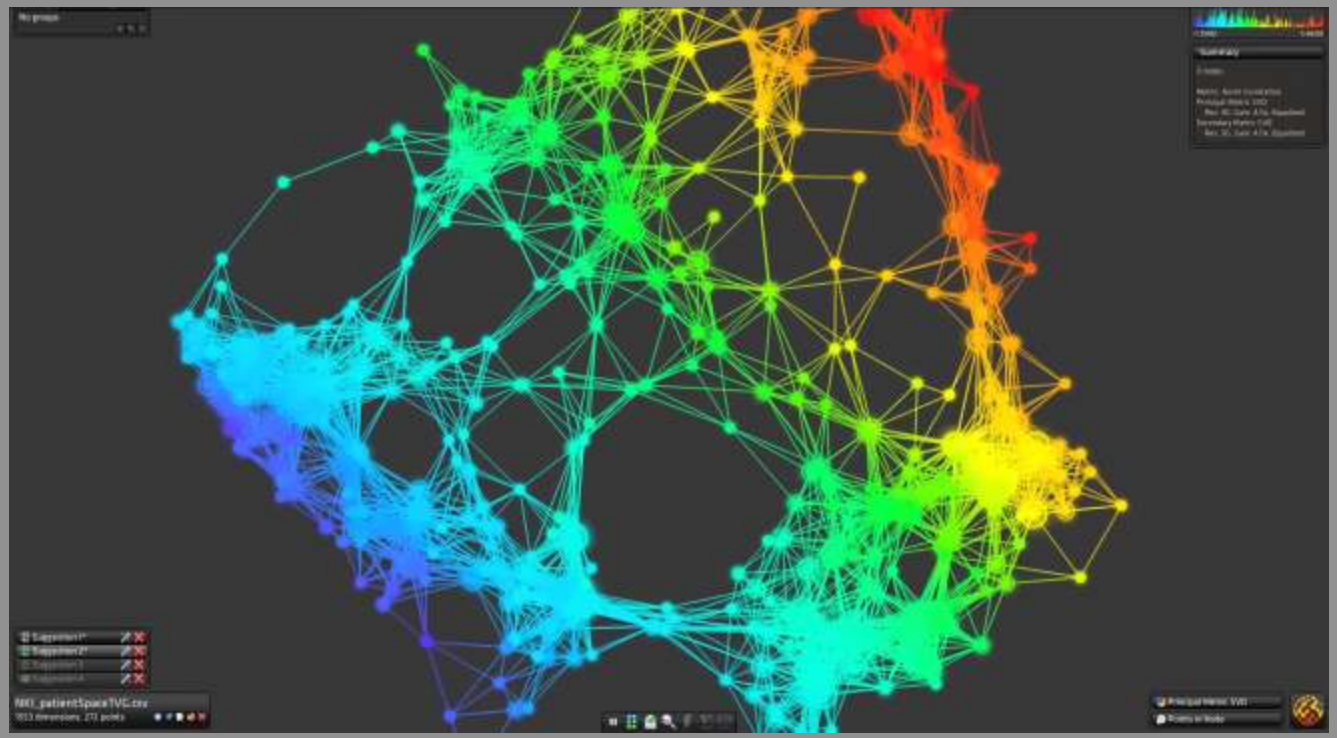
knol, et al., diabetologia (2006); rotella, journal of clinical psychiatry (2013)

visualize 800 terabytes of raw data from breast and ovarian cancer patients…

…and find genetic subpopulations to help mere mortals become cancer drug researchers

Ayasdi

*a khosla ventures investment



systems will surprise…

…“programming appears to think independently from its creators, and its complex cognitive processes are inscrutable”

clark, the register (2013)

kaggle data science competition:

outperformed 3 years of HIV research…

…in 1.5 weeks

the practice of medicine

the science of medicine

speculation: in the next 10 years…

…data science will do more for medicine than all biological sciences combined

I will be wrong on the specifics but directionally right

the shift to “computerization” has already happened in other areas…

…airline pilots, stock trading, car driving

humans don’t have built-in diagnostics

car

400+ on-board sensors
750MB/s data processed
in google self-driving car

iPhone

10+ on-board sensors
4 radios

human

0 on-board sensors
annual checkup (maybe)

the folly of experts: tetlock study

hundreds of “experts” …

28,000+ forecasts over 20+ years

results: “experts” are poorer forecasters than dart-throwing monkeys

the problem is not MDs…

…they have served us well in the "practice of medicine"…

…but humans are not good at the integrative "science of medicine"…

…or the misalignment of incentives

there aren’t enough rural doctors in india and few have access to jama journals, mris, …

…the world of medicine is under-resourced globally

well-informed patients often choose less aggressive and costly therapies

institute of medicine (2013)

20% doctor included?

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if banking were like health care, automated teller machine (ATM) transactions would take not seconds but perhaps days or longer as a result of unavailable or misplaced records.

if home building were like health care, carpenters, electricians, and plumbers each would work with different blueprints, with very little coordination.

if shopping were like health care, product prices would not be posted, and the price charged would vary widely within the same store, depending on the source of payment.

if automobile manufacturing were like health care, warranties for cars that require manufacturers to pay for defects would not exist. as a result, few factories would seek to monitor and improve production line performance and product quality.

if airline travel were like health care, each pilot would be free to design his or her own preflight safety check, or not to perform one at all.

institute of medicine (2013)

latest breakthrough from social scientists:
watching tv causes autism

wallis, time (2006)

substantial work is required to identify high-quality evidence that minimizes the risk of contradiction by later studies and is sufficiently robust to provide insight on application to a particular patient's clinical circumstances

institute of medicine (2013)

don’t get caught in the hype…

big data is like teenage sex:
everyone talks about it,
nobody really knows how to do it,
everyone thinks everyone else is doing it,
so everyone claims they are doing it...

dan ariely

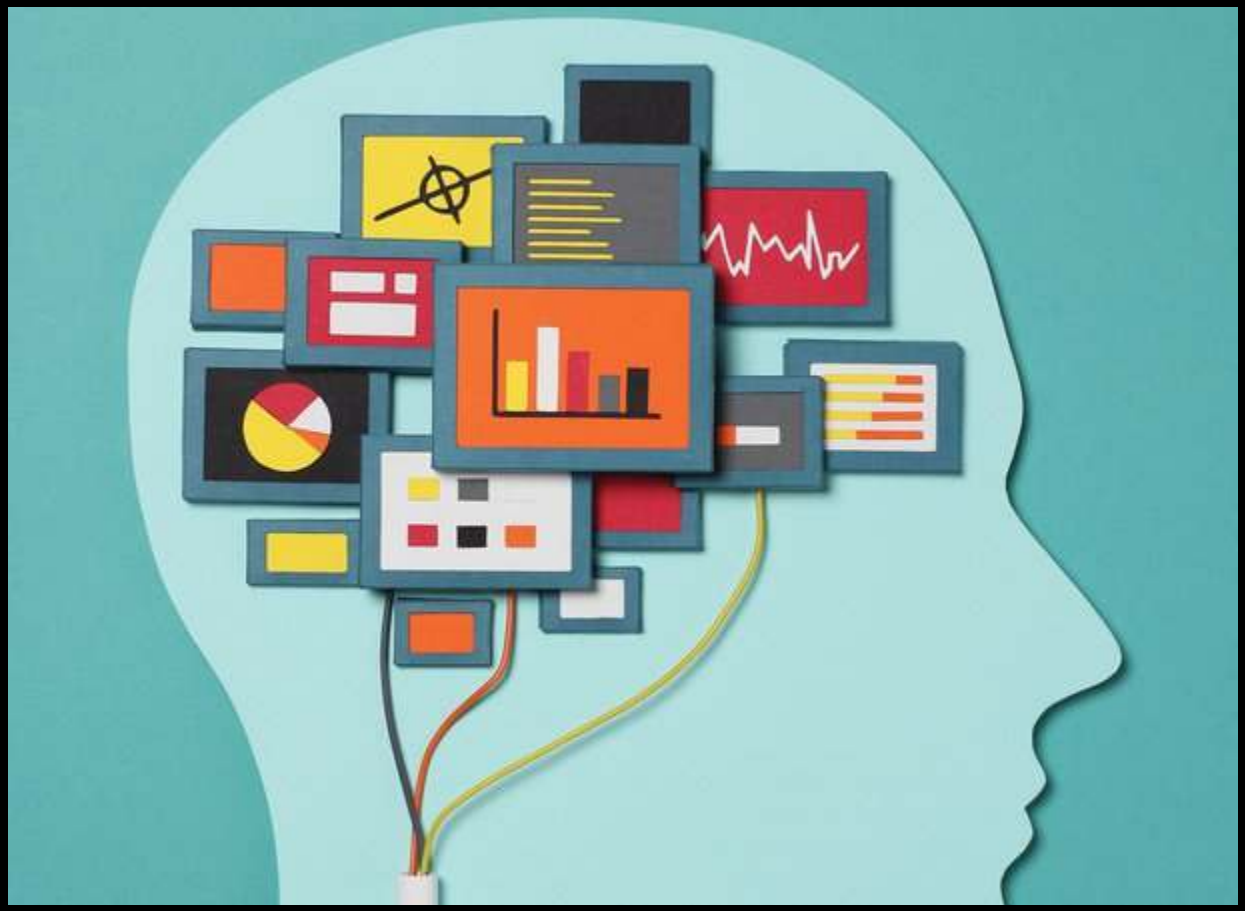
nearly half of all american adults have difficulty understanding and acting upon health information

institute of medicine (2004)

smart computers can be objective cost minimizers…

…while being care optimizers

but does automation make us simpletons?



carr, the atlantic (2013)

detect asthma, lung cancer, and other conditions inside the body…

…by just breathing

Adamant

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NO_x: 40ppm
Adamant Technologies