

# 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://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...

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

...premature closure was  
the single most common cause

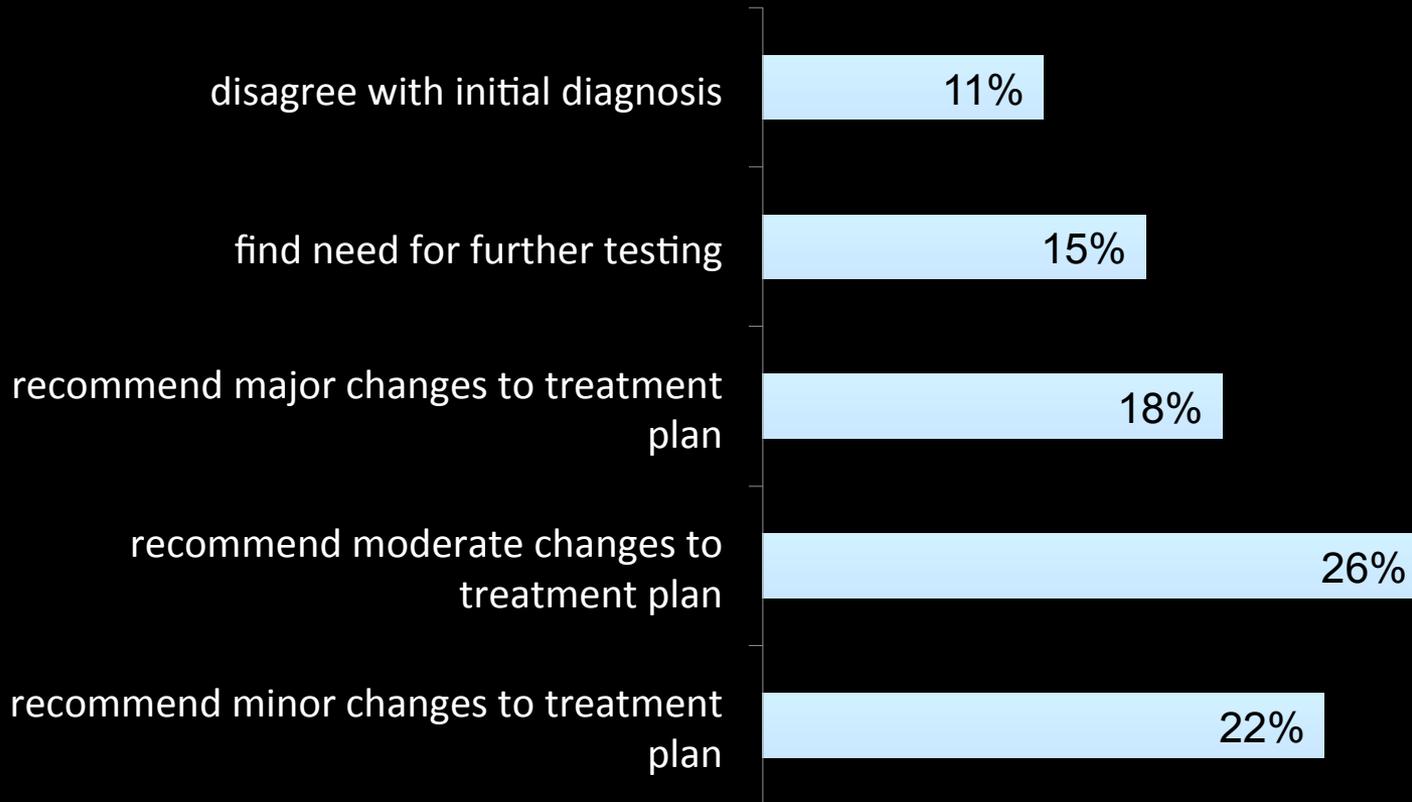
in many records of patients with a high-risk diagnosis, high-information clinical findings were present before the diagnosis was established

feldman, et al., jamia (2012)

# the value of second opinions

## cleveland clinic doctors' review of initial diagnosis

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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

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

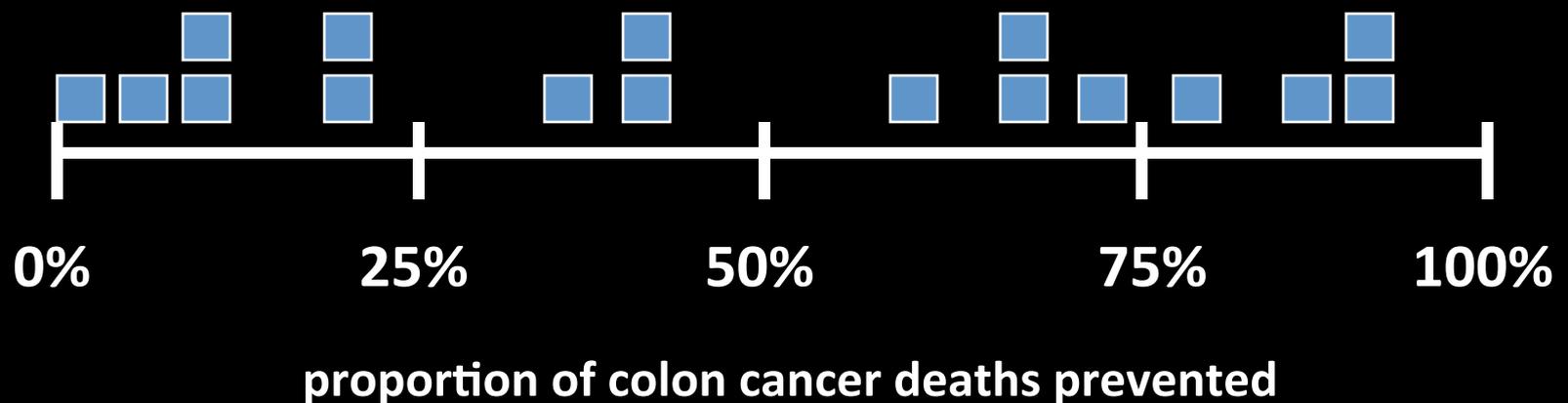
# fifty-eight experts' estimates of the chance of an outcome of an important procedure

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?

# wide ranges of uncertainty

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



■ = one expert's response

# 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”

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

the current guideline suggesting  $\beta$ -blockers before serious surgery is pretty effective...

...at increasing risk of mortality by 27%

medical wisdom upended...

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

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

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

new computer models analyze microscopic  
breast cancer images...

...and predict patient survival better than  
today's pathologists

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...**

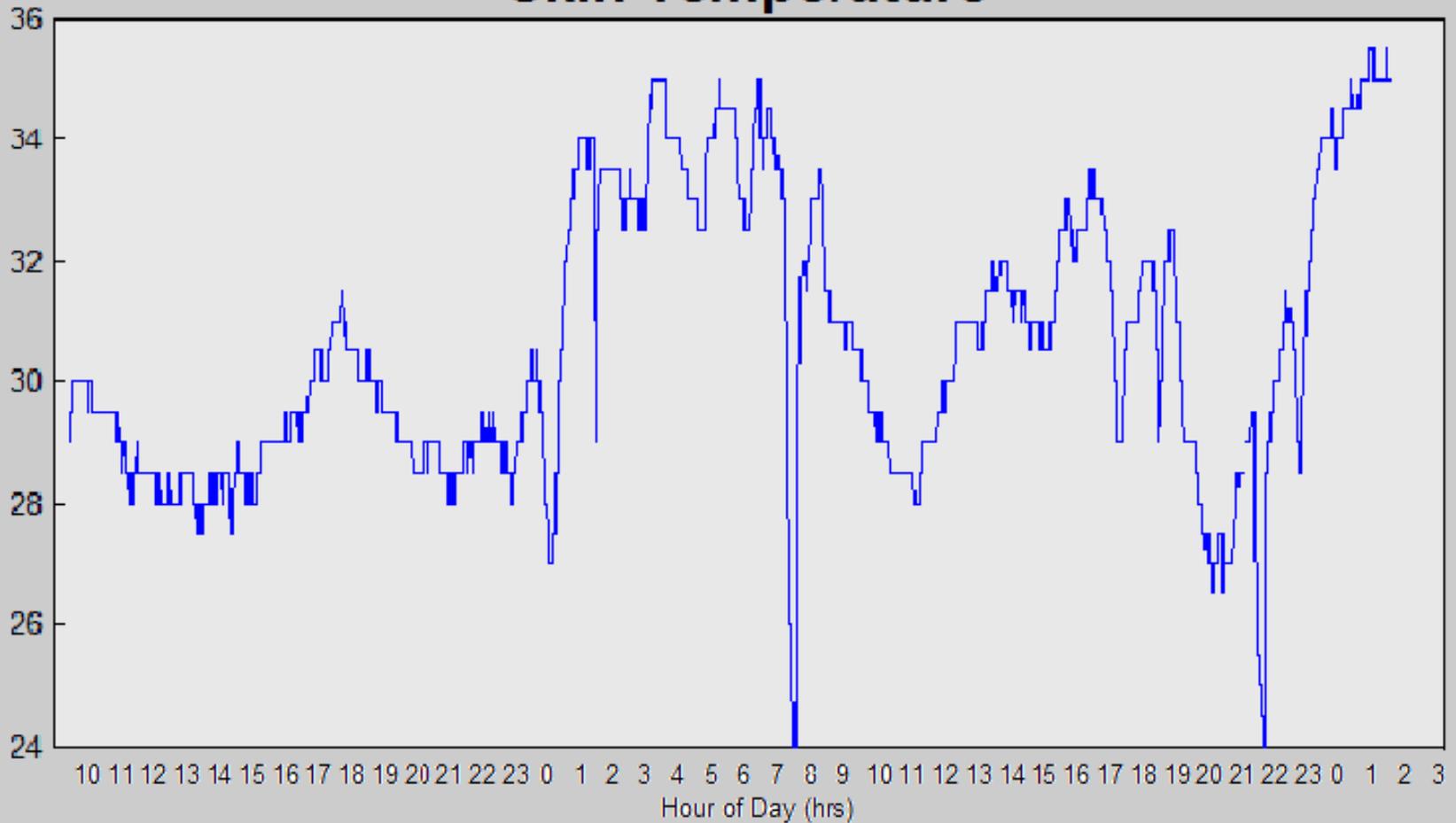
**...take your own ecg  
anytime, anywhere, for less than \$1...  
...and know you have heart disease  
before you have an attack!**

**AliveCor**

\*a khosla ventures investment



# Skin Temperature



**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...**

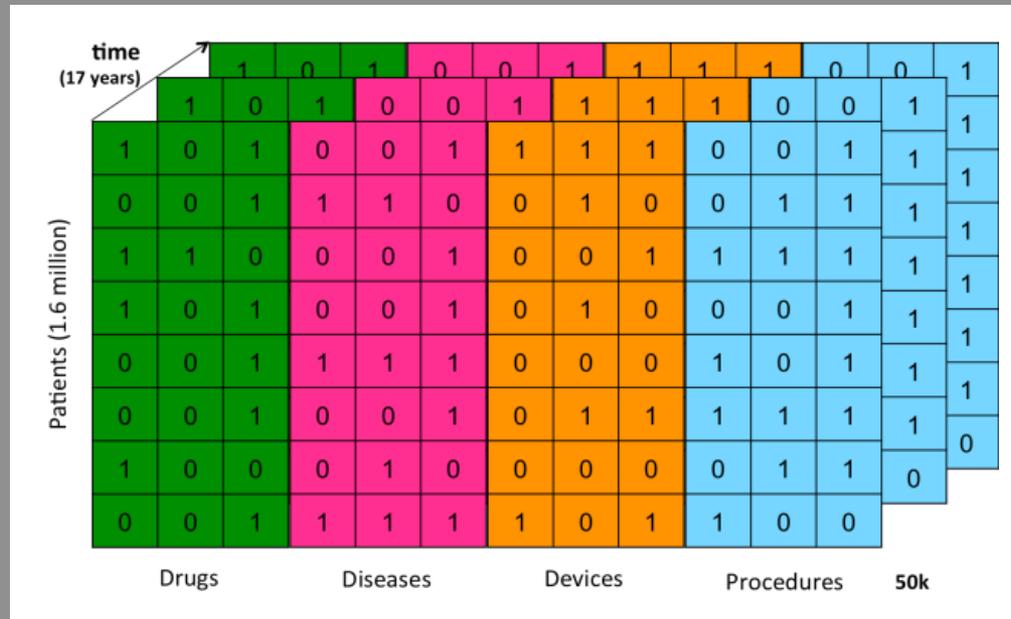
**...and algorithmically create  
new clinical guidelines...**

**...using practice-based evidence**

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

**Kyron**

\*a khosla ventures investment



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: diabetes risk factors

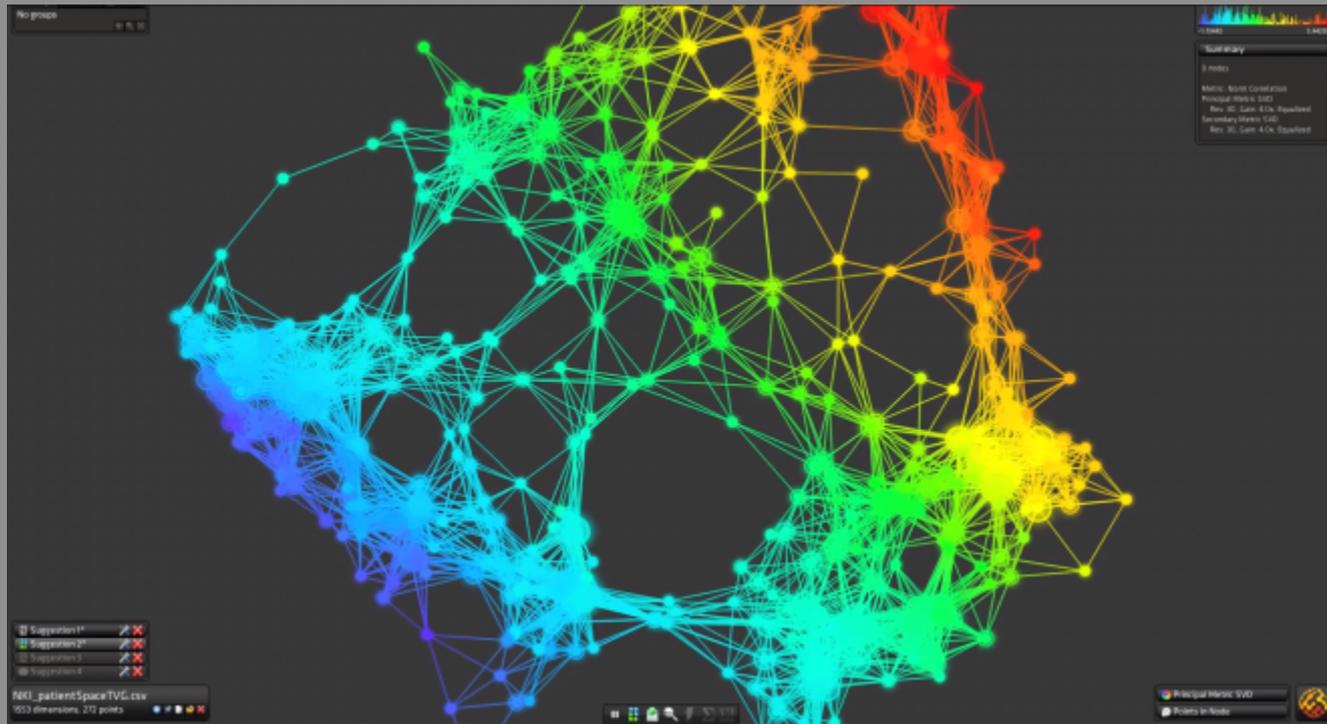
depression  
taking statins  
staying up late at night

**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”

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

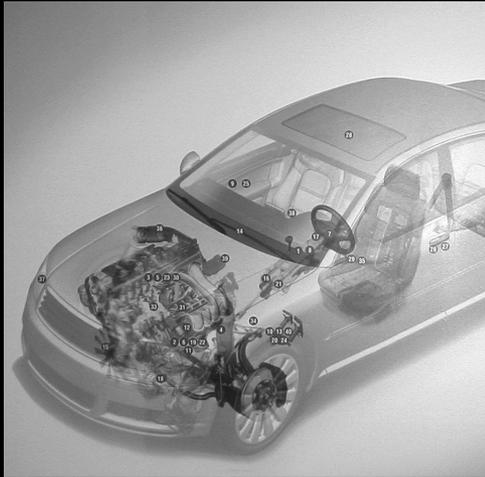
I will be wrong on the specifics but  
directionally right

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

...airline pilots, stock trading, car driving

# humans don't have built-in diagnostics

car



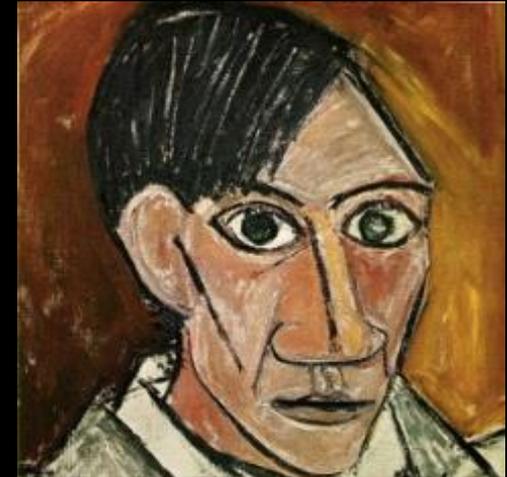
400+ on-board sensors  
750MB/s data processed  
in google self-driving car

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.



latest breakthrough from social scientists:  
watching tv causes autism

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?



**detect asthma, lung cancer, and  
other conditions inside the body...**

**...by just breathing**

**Adamant**

\*a khosla ventures investment

