

Individualising Health Care

Via Data

DataRobot

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Before Modern Medicine

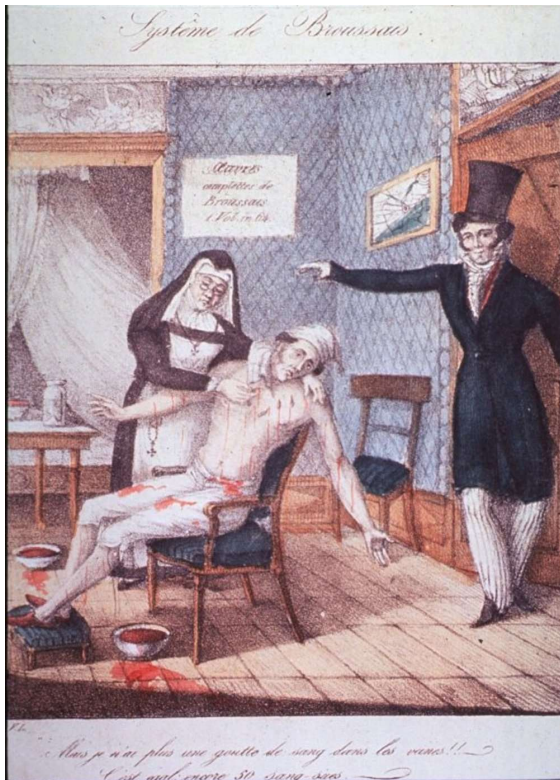
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The First Surgery



The first recorded surgery occurred in Egypt almost 5,000 years ago.

Blood, leeches and knives



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Bloodletting originated in Egypt over 3000 years ago and continued to be practiced until early last century.

The patient was cut to drain blood, plus they put leeches on him!

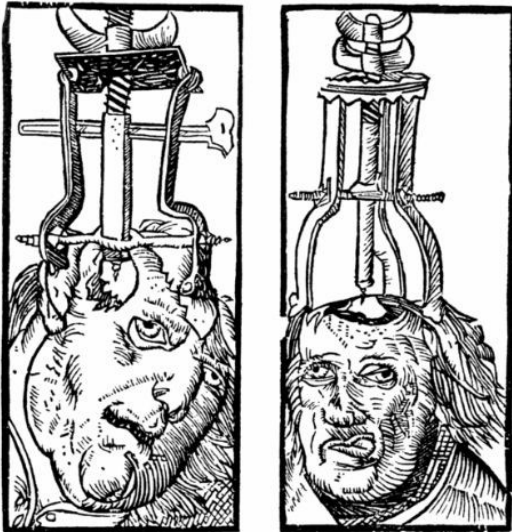
Superstition and Myth



Treatments were usually ineffective because they not based upon objective evidence.

This resulted in bizarre treatments such as powder made from ground-up Egyptian mummies!

Superstition and Myth



Often the treatment was worse than the disease, including:

- Drilling holes in the head for migraine
- Heroin cough syrup

Life Expectancy Was Short



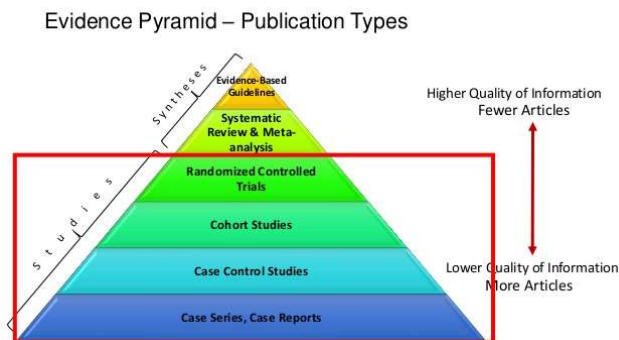
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- In 1543 the life expectancy in UK was 34 years
- In 1891 the life expectancy in India was 24 years
- In 1927 the life expectancy in Indonesia was 30 years
- In 1930 the life expectancy in China was 32 years

Modern Medicine

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Scientific Method



Carefully designed experiments.

The introduction of statistical analysis.

Distinguishing myth from fact.

Evidence Based Guidelines

**Developing evidence-based
guidelines at WHO**



**World Health
Organization**

Guidelines and
standard practices
for medical
practitioners,
backed by clinical
evidence.

Life Expectancy More Than Doubled



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- In 2011 the life expectancy in UK was 81 years
- In 2009 the life expectancy in India was 65 years
- In 2009 the life expectancy in Indonesia was 70 years
- In 2009 the life expectancy in China was 74 years
- In 2009 the life expectancy in Singapore was 81 years

Life Expectancy More Than Doubled

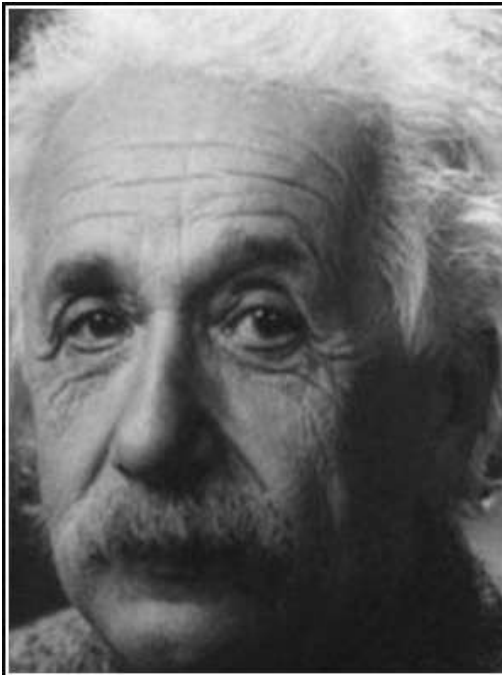


- My grandmother was lucky enough to live to see this progress
- This is a photo from her 100th birthday party
- She lived to the age of 103!

Health Care and Individuality

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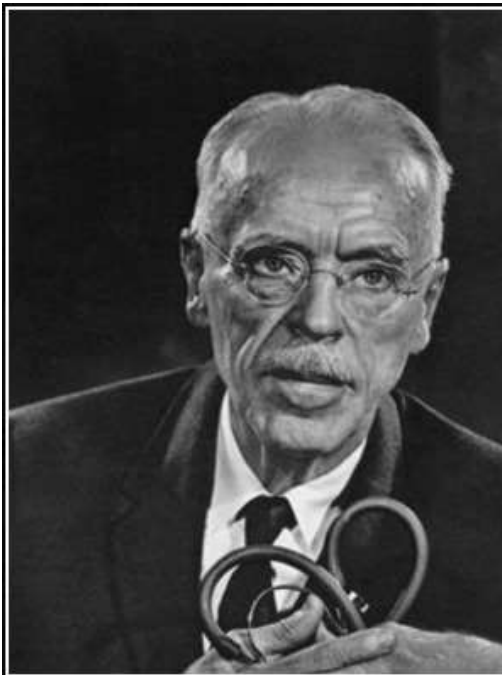
The Rise of Individuality



It is important to foster individuality, for only the individual can produce the new ideas.

— *Albert Einstein* —

The Value of Individuality

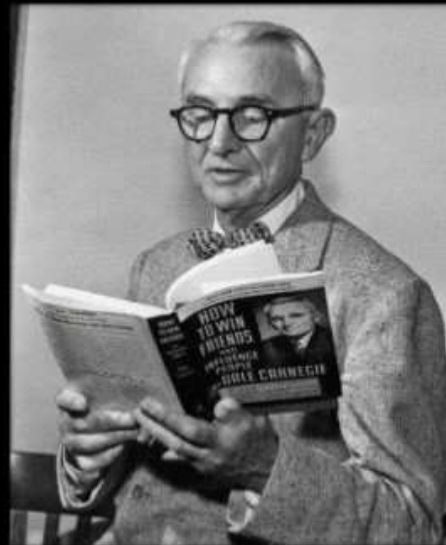


We know from our clinical experience
in the practice of medicine that in
diagnosis, prognosis, and treatment,
the individual and his background of
heredity are just as important, if not
more so, as the disease itself.

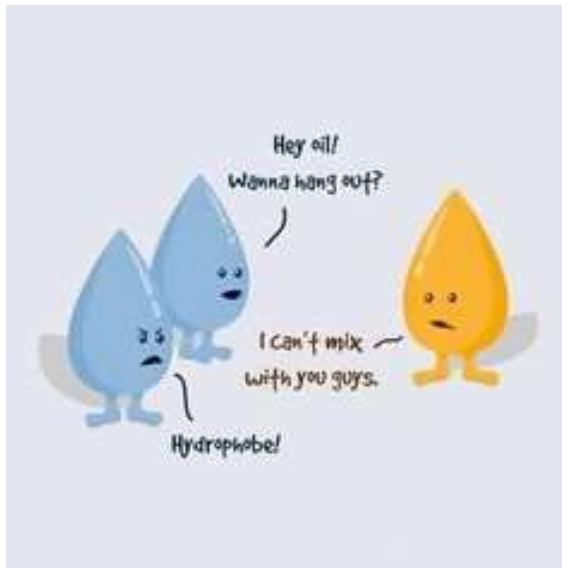
— *Paul Dudley White* —

Personalising Medicine

“Remember that a **person's name** is to that person the sweetest and most important sound in any language”.
– **Dale Carnegie**



The Challenge

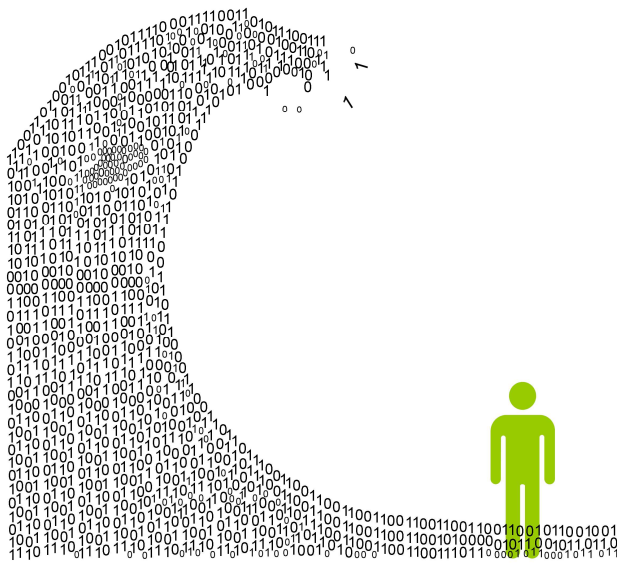


- Standardised experiments and individualisation are like oil and water
- It's impractical to create large scale experiments with proper controls for ALL the individual factors

A Way Forward

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Big Data



- There's already big data out there and there's more to come!
- Text: Patient notes
- Images: MRI scans
- Behaviour: fitness trackers
- IoT (Internet of Things)

Too Much Data?



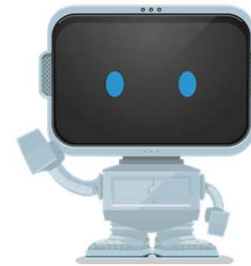
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- Before the invention of the printing press, books were hand-written.
- This made books scarce.
- Controlled experiments are manual and expensive.
- They are designed for times when data was scarce.
- They aren't designed to scale for big data.

Statistics vs. Machine Learning



versus



- Statistics: Hypothesis testing e.g. is this medical treatment effective?
- Machine Learning: Pattern finding and extrapolation e.g. which patients are currently at highest risk?

Case Study: Disease Progression

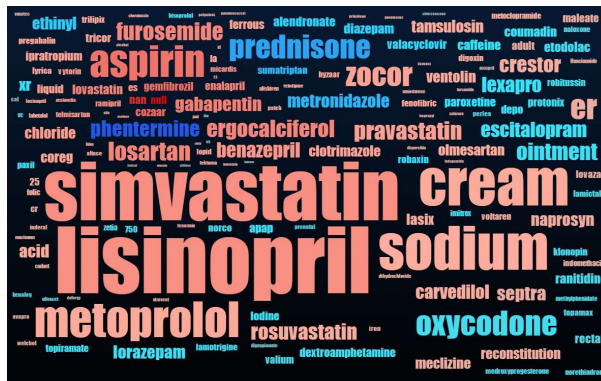
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Who Has Undiagnosed Diabetes?



- The American Diabetes Association says that more than 25 million people in USA have diabetes, and of those, only 19 million have been formally diagnosed with the disease...

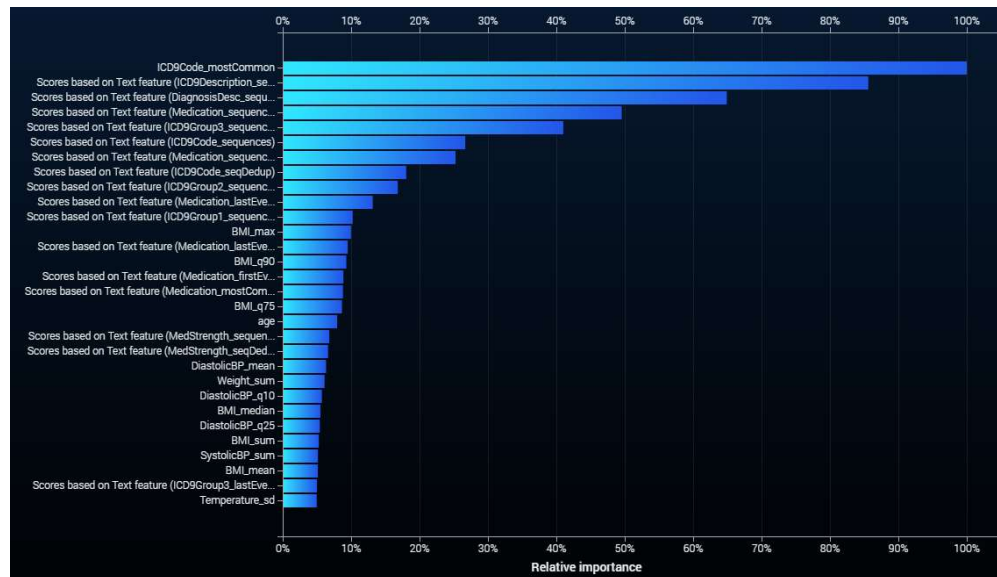
Text Mining



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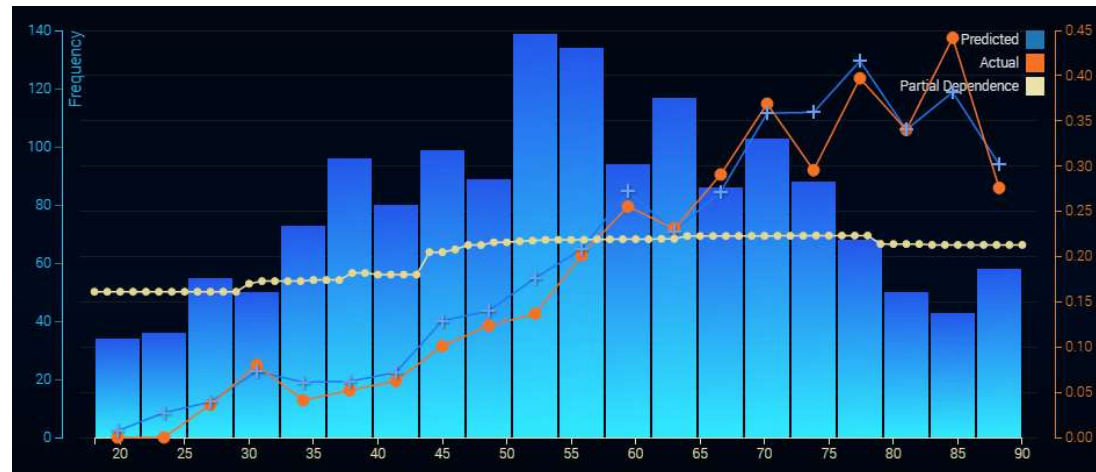
- There is a wealth of information in text that traditional statistics mostly ignores
- We can find indicators from diagnosis descriptions, prescriptions and lists of medications

Text Mining



- For this case study, text based features had the strongest predictive power of all of the data collected

Controlling for Other Effects



- As expected, the prevalence of diabetes increases with age
- But after controlling for other effects (e.g. medical history), age is not the key driver (except the jump in the mid 40s)

Individualisation

ID	PREDICTION	REASONS
1	0.975	+++ Medication_sequ... = "_NOEVENTS_" +++ Medication_Jast... = "_NOEVENTS_" --- BMI_max = 48.92100000000001
2	0.969	+++ Medication_sequ... = "_NOEVENTS_" +++ Medication_Jast... = "_NOEVENTS_" +++ Medication_most... = "_NOEVENTS_"
3	0.959	+++ Medication_sequ... = "_NOEVENTS_" +++ Medication_Jast... = "_NOEVENTS_" --- ICD9Group2_Jast... = "Hypertensive..."
4	0.002	--- age = 30 --- Medication_sequ... = "Loestrin 24 Fe..." --- Medication_firs... = "Loestrin 24 Fe..."
5	0.002	--- age = 20 --- Medication_sequ... = "Pristiq..." --- BMI_median = 18.408
6	0.002	--- age = 36 --- Medication_sequ... = "Tri-Sprintec..." --- Medication_firs... = "Tri-Sprintec..."

- We can provide a probability estimate that an individual patient has undiagnosed diabetes
- A doctor can use this probability score to act early and maybe even prevent diabetes!
- We can even give reasons for this probability.

Case Study: Sepsis

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Who Will Get A Sepsis Infection?



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- Sepsis is the body's often deadly response to infection or injury.
- Sepsis requires early treatment for survival.
- You're more likely to develop sepsis if:
 - you've recently had surgery
 - you've had a urinary catheter fitted
 - you have to stay in hospital for a long time

Existing Sepsis Screening

- Inflexible rules that ignore individual differences and variations



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1. History of a new infection: checklist of common sites of infection
2. Signs/symptoms of infection: temperature $>38.3^{\circ}\text{C}$ or $<36^{\circ}\text{C}$, heart rate >90 beats/min, respiratory rate >20 breaths/min, acutely altered mental status, white blood cell count $>12,000\ \mu\text{L}$ (or $12\ \text{K}/\mu\text{L}$) or $<4000\ \mu\text{L}$ (or $4\ \text{K}/\mu\text{L}$), and plasma glucose $120\ \text{mg}/\text{dL}$ in the absence of diabetes
3. Criteria for organ dysfunction: systolic blood pressure $<90\ \text{mm Hg}$ or decrease $>40\ \text{mm Hg}$ from baseline, mean arterial pressure $<65\ \text{mm Hg}$, bilateral pulmonary infiltrates with increasing oxygen requirements to maintain $\text{SpO}_2 >90\%$ or $\text{PaO}_2/\text{FIO}_2$ ratio <300 , creatinine $>2.0\ \text{mg}/\text{dL}$, bilirubin $>2\ \text{mg}/\text{dL}$, platelet count $<100,000/\mu\text{L}$ (or $100\ \text{K}/\mu\text{L}$), coagulopathy, or lactate $>2\ \text{mmol}/\text{L}$

Source: <http://www.sccm.org/Communications/Critical-Connections/Archives/Pages/Rapid-Identification-of-Sepsis---The-Value-of-Screening-Tools.aspx>

How Can Sepsis Be Predicted?



- Build a machine learning model
- The key inputs / predictors are
 - The patient's medical history
 - Medical charts (especially temperature)
 - Other sepsis infections in the hospital

Individualisation

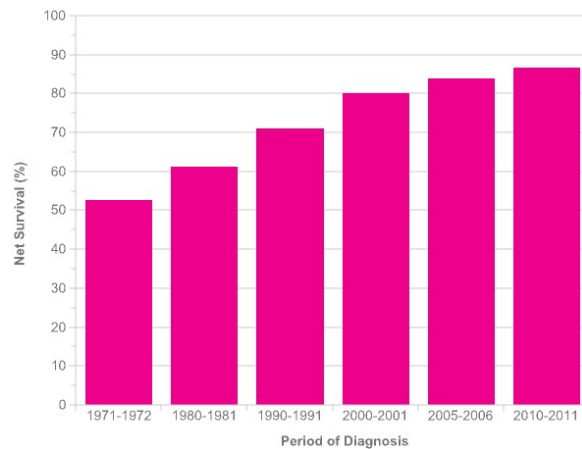


- Hospitals in USA have started operationalising predictive modelling of sepsis
- Flexible scoring that adjusts for an individual's
 - medical history
 - symptoms
 - environmental factors
- Hourly score updates

Case Study: Breast Cancer Survivors

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Life Insurance For Cancer Survivors



Source: www.cancerresearchuk.org

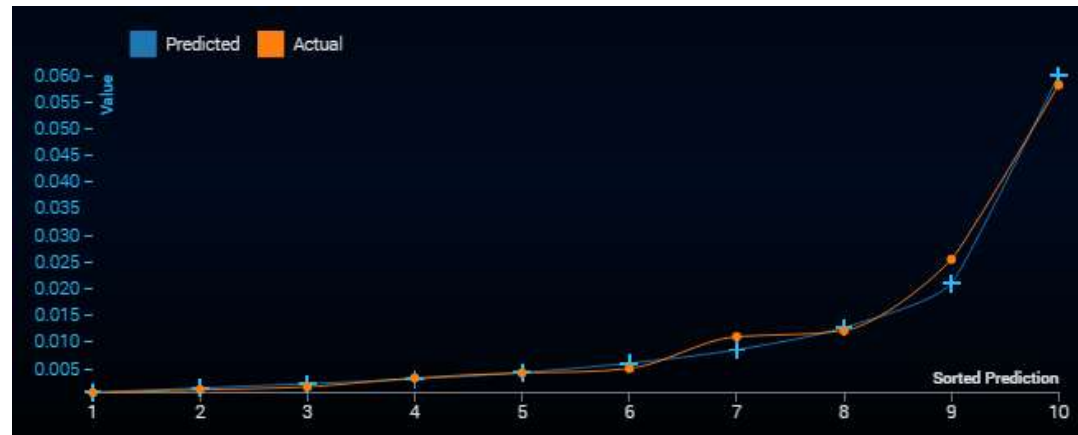
- 30 years ago, I lost my mother to breast cancer.
- But due to advances in medical science since then, the survival rate has increased dramatically.

Starting a New Life After Cancer



- Survivors of cancer want to get on with their lives
- They want to buy a house
- But to get a mortgage they need life insurance
- To get life insurance, actuaries must price post-cancer mortality rates

Most Survivors Have Low Mortality



- We can build a complex predictive model that allows for an individual's medical history and circumstances
- It shows that 80% of survivors have good mortality rates and 30% have extremely good mortality rates

Individualisation

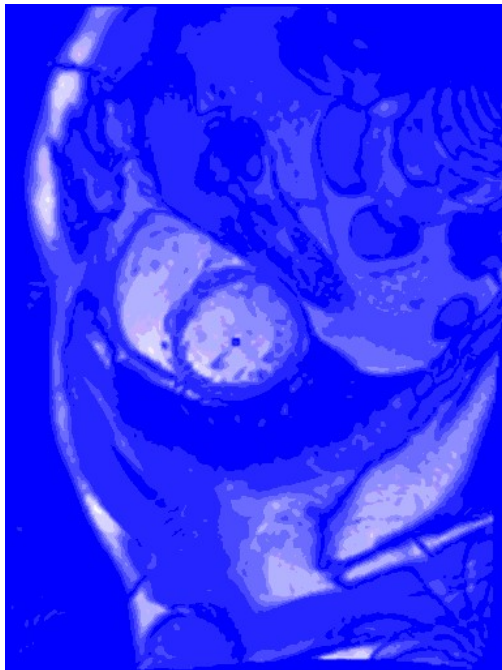
ID	PREDICTION	REASONS
1	0.375	+++ EOD10_PN = 10 +++ AGE_DX = 91 +++ GRADE = 3
2	0.356	+++ CS_SIZE = 170 +++ EOD10_PN = 13 --- EOD10_NE = 20
3	0.314	+++ EOD10_PN = 8 +++ GRADE = 3 +++ EXTEVAL = 6
4	0.000	--- DURATION = 0 --- HISTO2V = 8050 --- GRADE = 1
5	0.000	--- DURATION = 0 --- GRADE = 1 --- HISTO2V = 8211
6	0.000	--- DURATION = 0 +++ CS_SSF5 = MISSING --- GRADE = 1

- We can provide detailed mortality rate estimates for individual patients
- We can even give reasons why we think a person is a good life insurance risk

**The Future is
Coming Sooner
Than You Think...**

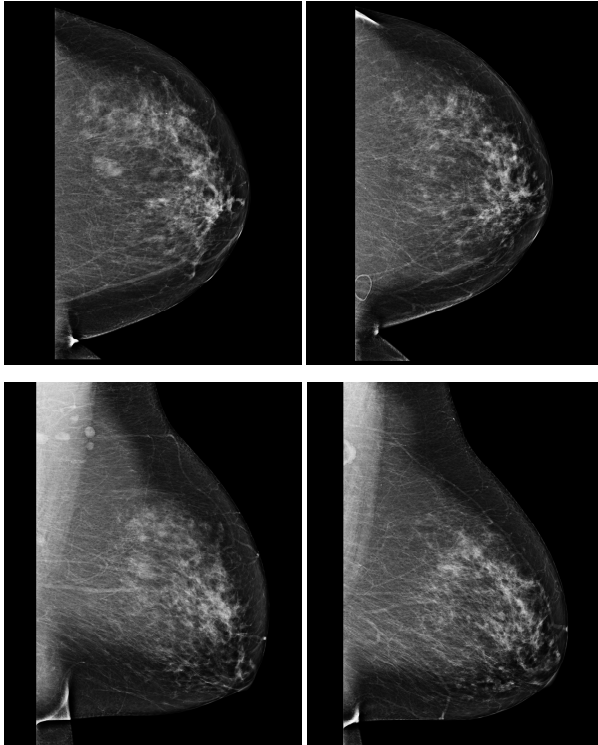
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Heart Disease

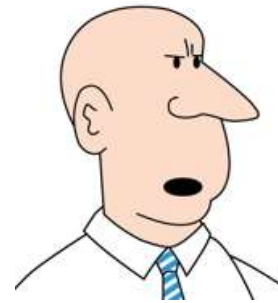


- Using 3D MRIs (magnetic resonance imaging)
- Across the entire cycle of a heartbeat
- We can automatically identify problems with volume of chamber and blood flow
- The best models are more accurate than humans

Mammograms



- Using 2D MRIs (magnetic resonance imaging)
- From 2 different angles
- We can identify whether the patient has breast cancer
- Maybe we will be able to do this earlier and more accurately than doctors!



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Questions?