Big Data in Healthcare

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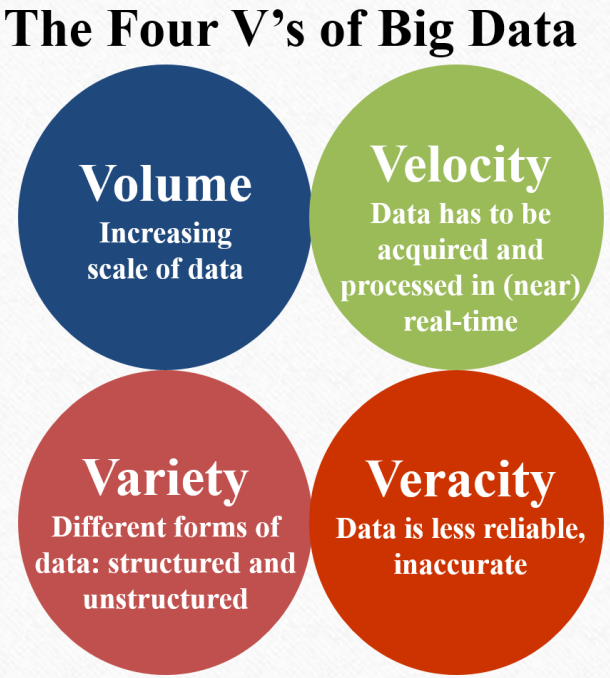
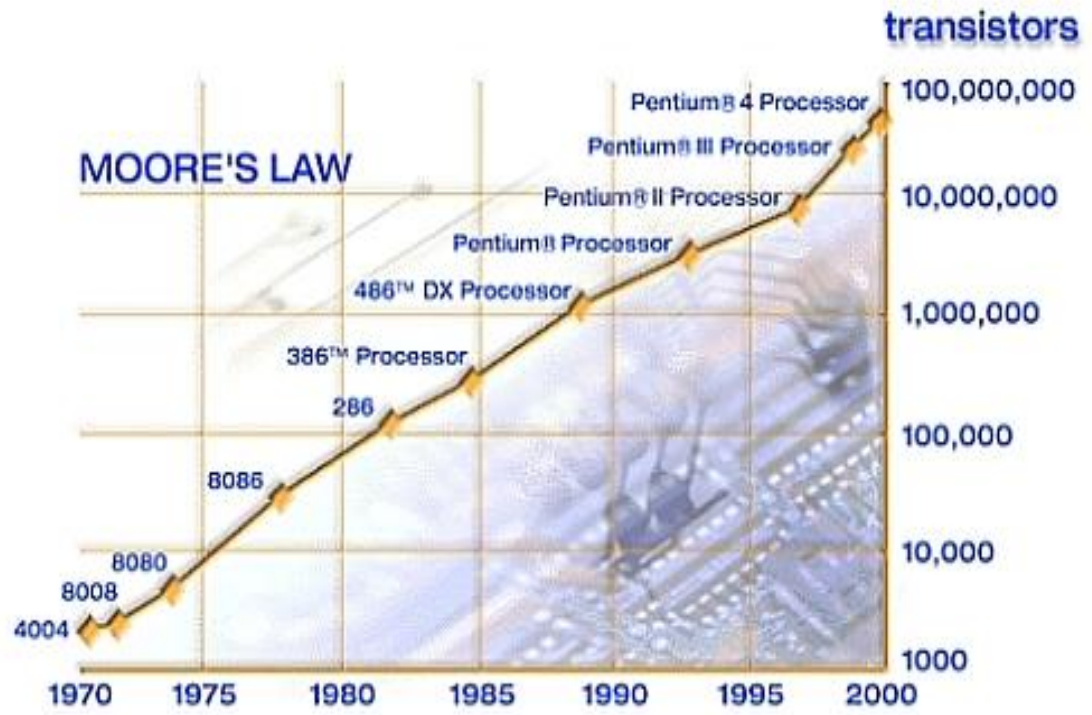
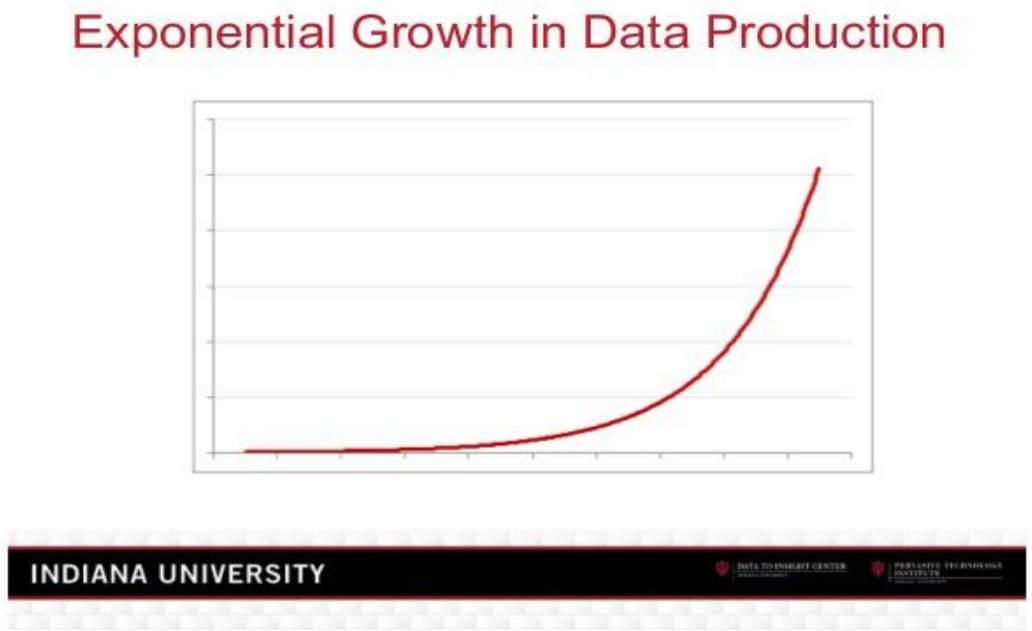
What is **Big Data**?

- Quite nebulous, in the same way that the term "cloud" covers diverse technologies
- To clarify matters, the four Vs: **Volume**, **Velocity**, **Variety** and **Veracity** are commonly used to characterize different aspects of.



Big Data – **Exponential Growth**

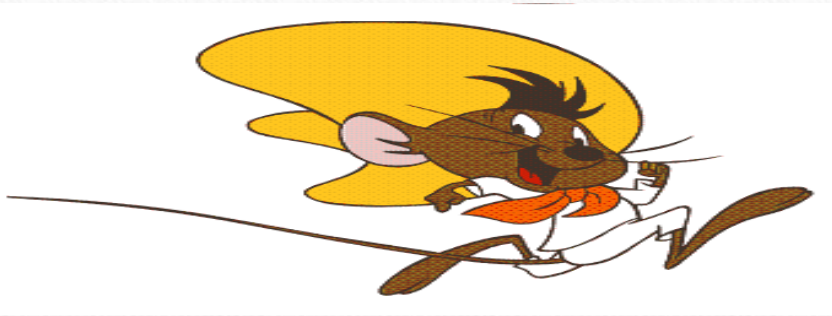




Big Data - **Volume**

- Refers to the vast amounts of data generated and shared every second: emails, twitter messages, photos, video, sensor data etc.
- **From 2013 to 2020, the digital universe will grow by a factor of 10 – from 4.4 trillion gigabytes to 44 trillion.**
- It more than doubles every two years (~Moore's Law).
- Nowadays, in a single day we process amounts equivalent to decades and centuries – from Megabytes (2^{10}B) to Exabytes (2^{60}B), Zettabytes (2^{70}B) and Yottabytes (2^{80}B)

Big Data - **Velocity**



- Refers to the speed at which:
  - new data is generated
  - data moves around
  - data is required to be processed
- Examples:
  - Need to check credit card transactions for fraudulent activities as soon as possible
  - Competition among trading systems in their ability to quickly analyze social media networks to pick up signals that trigger decisions to buy or sell shares

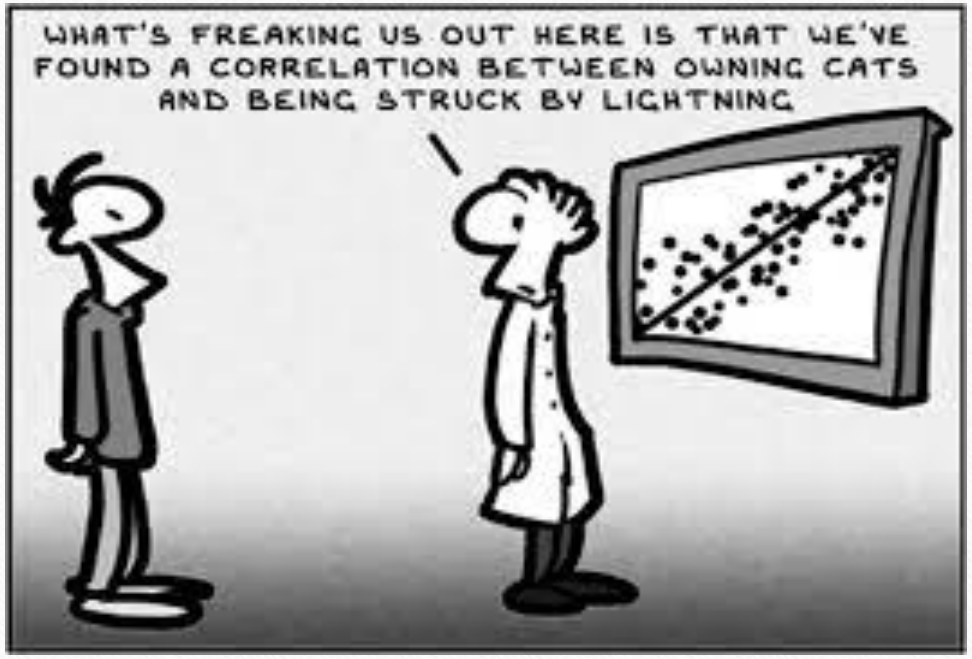
Big Data - **Variety**

- Refers to the different types of data we can now use
- In the past we focused on **structured data** that neatly fits into tables or relational databases - easy to manipulate, store and analyze.
- Today, however, the majority of the world's data is **unstructured data** (e.g. photos, video sequences, blogs or social media updates), and cannot be easily converted into structured data.

Big Data - **Veracity**

- Refers to the messiness or trustworthiness of the data, biases, noise and abnormality in data

- With many forms of Big Data, quality and accuracy are less controllable.



The Data Revolution & Evolution

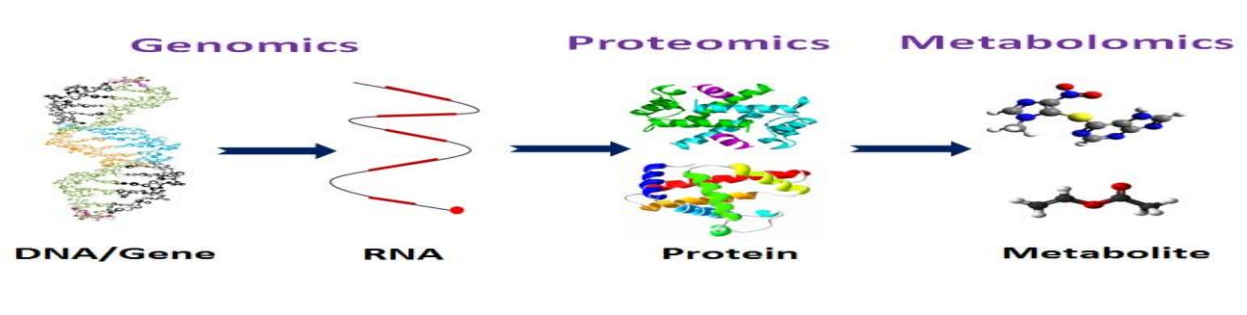
FROM	TO
Data as a fact of life	Data as a factor of production
Collecting	Connecting
Analyzing	Predicting
Information	Insights
"One version of the truth"	Multiple sources and perspectives
Structured	Unstructured
Relational	Non-relational
Centralized processing	Distributed parallel processing
Terabytes	Petabytes, exabytes, ...
Analytics as niche	Analytics for everyone
Limited participation	An era of experimentation and innovation

Healthcare's (Big) Data

Big Data in healthcare can be broadly summarized into three categories:

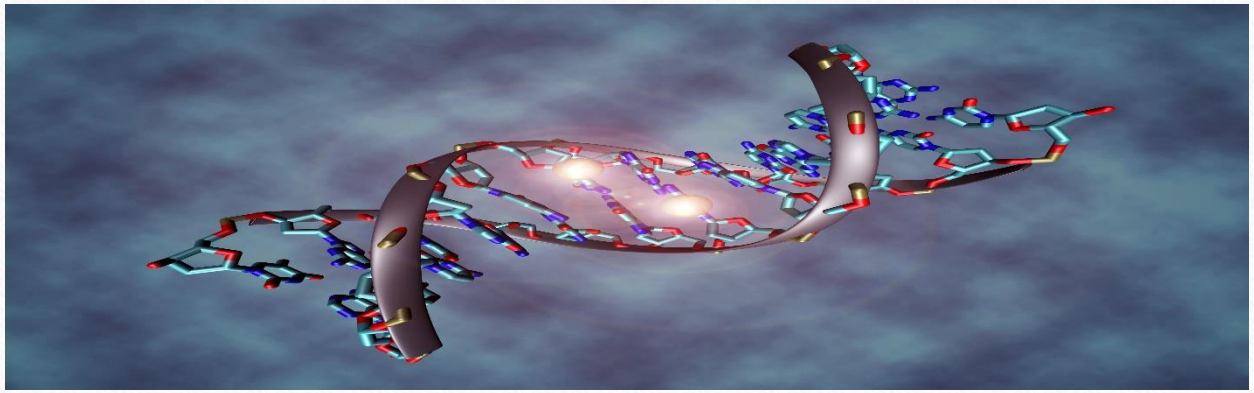
- **Traditional medical data** - primarily originated from electronic medical records (EMRs)
- **"Omics" data** - refer to large-scale datasets in the biological and molecular fields
- **Patient Generated Data (PGD)**

“Omics” Data



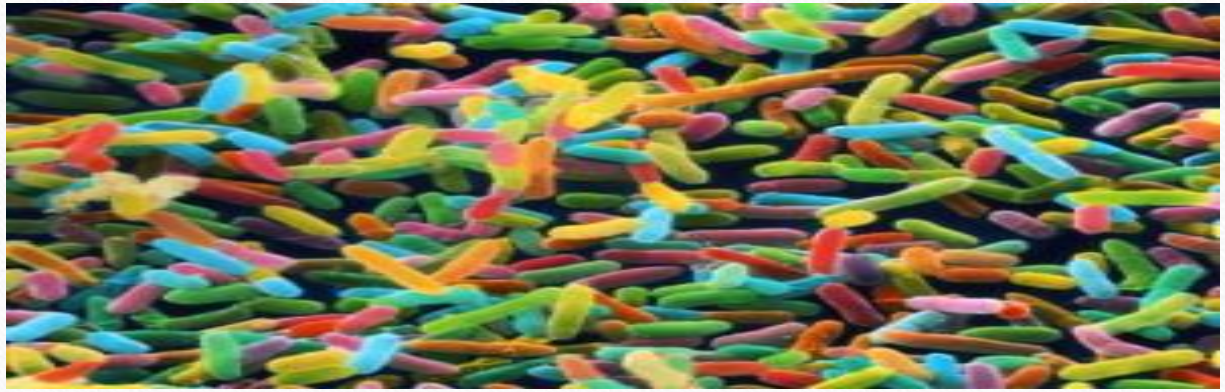
- Include: genomics data, transcriptomics (the set of all RNA molecules), proteomics data, metabolomics, protein-DNA interactions, protein-protein interactions, phenomics (biomarkers), **epigenetics**, **microbiomics**, lipidomics etc.
- Analyzing this data yields understanding of the **mechanisms of diseases** and acceleration of the **individualization of medical treatments** (e.g. “precision medicine”).

Epigenetics



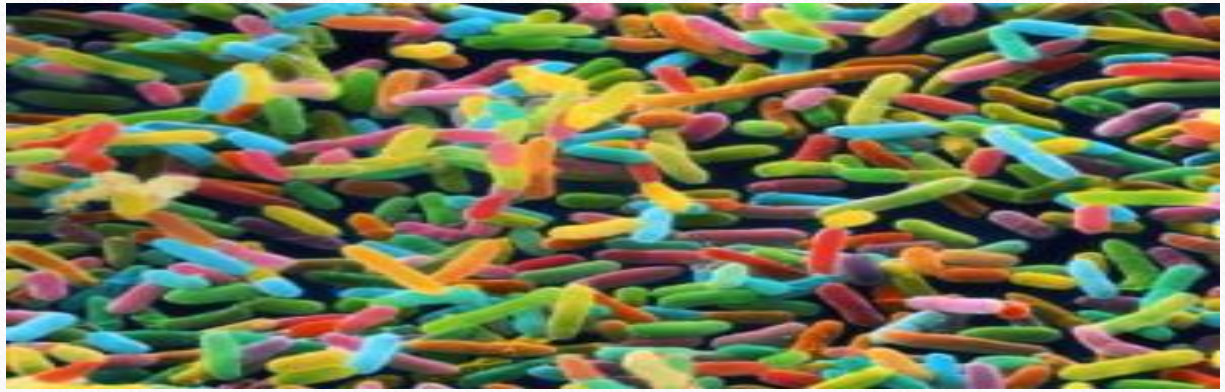
- The study of changes in gene expression or cellular phenotypes, caused by mechanisms other than changes in the underlying DNA sequence
- Some of these changes have been shown to be heritable.
- For example, prions (infectious proteins) are clearly epigenetic, perpetuating themselves through altered folding states.

Microbiomics



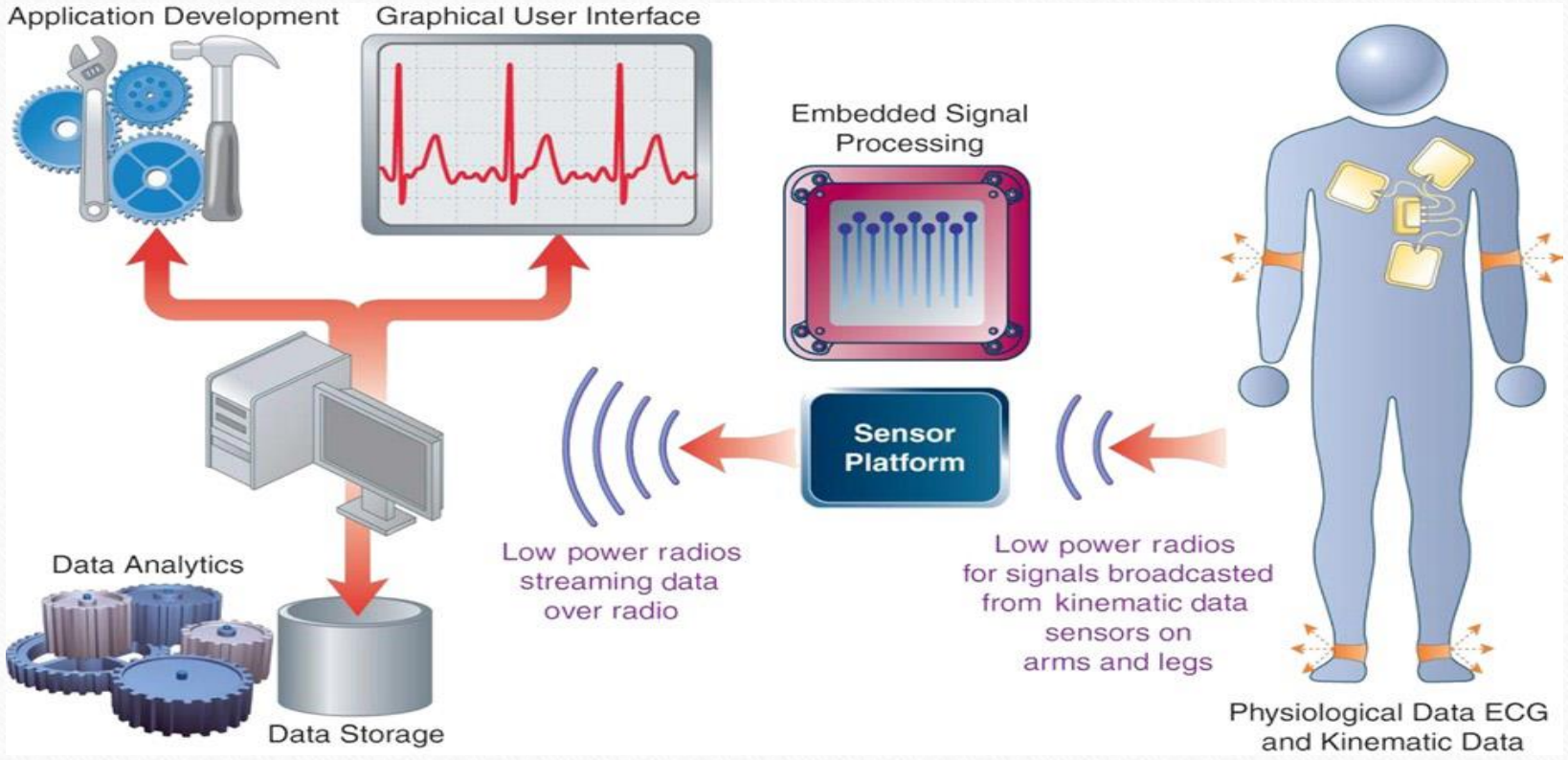
- The **microbiome** is the collective existence of non-human cells in the human body.
- **An estimated 90% of cells found in the human body are not human at all.**
- Though considerably smaller in size, these approximately **100 trillion cells add up to a mass of almost 1–2 kg in an adult individual**.

Microbiomics



- Recently, increasingly viewed as a new human organ.
- The microbiome has been associated with both health and a growing number of human diseases and conditions.
- Examples: irritable bowel syndrome, obesity, diabetes, asthma, arthritis, cardiovascular disease, and autism

PGD – Patient Generated Data

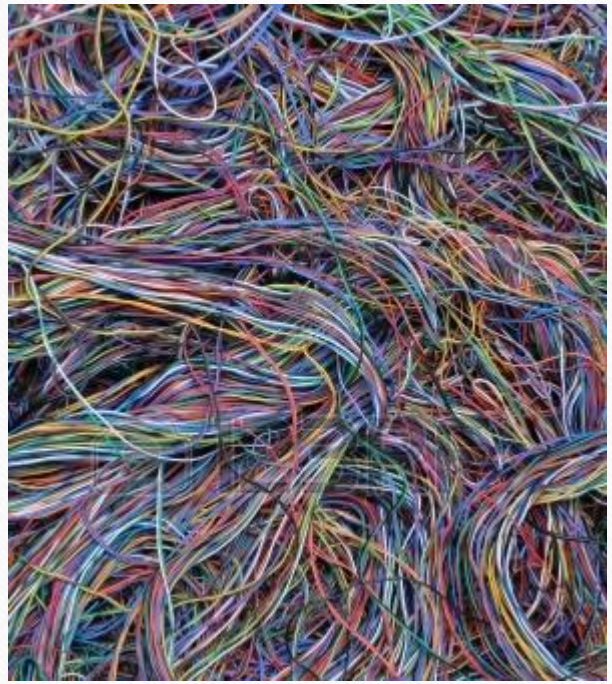


PGD Examples

- Google has developed a smart contact lens diabetics can use to read blood sugar levels through the tears in their eyes, providing a new glucose reading as often as once a second.
- Ralph Lauren has unveiled recently the Polo Tech, a compression shirt outfitted with sensors. The biometric shirt operates like a Fitbit, providing information on heart rates and stress levels.

Information Chaos

- Healthcare providers, the physicians and the patients have more data than ever before:
  - Physicians through the EMRs
  - Patients through a ePHRs, mHealth apps, PGD (e.g. sensors)
- And we keep talking about patient empowerment…



Cancer

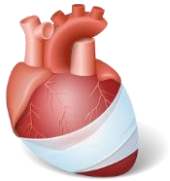
Alzheimer's Disease

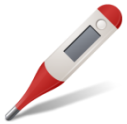
High Blood Pressure

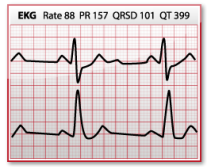
Hearth Disease

Glaucoma

Allergy







Epilepsy

CKD

Obesity

Psoriasis

Diabetes

Depression

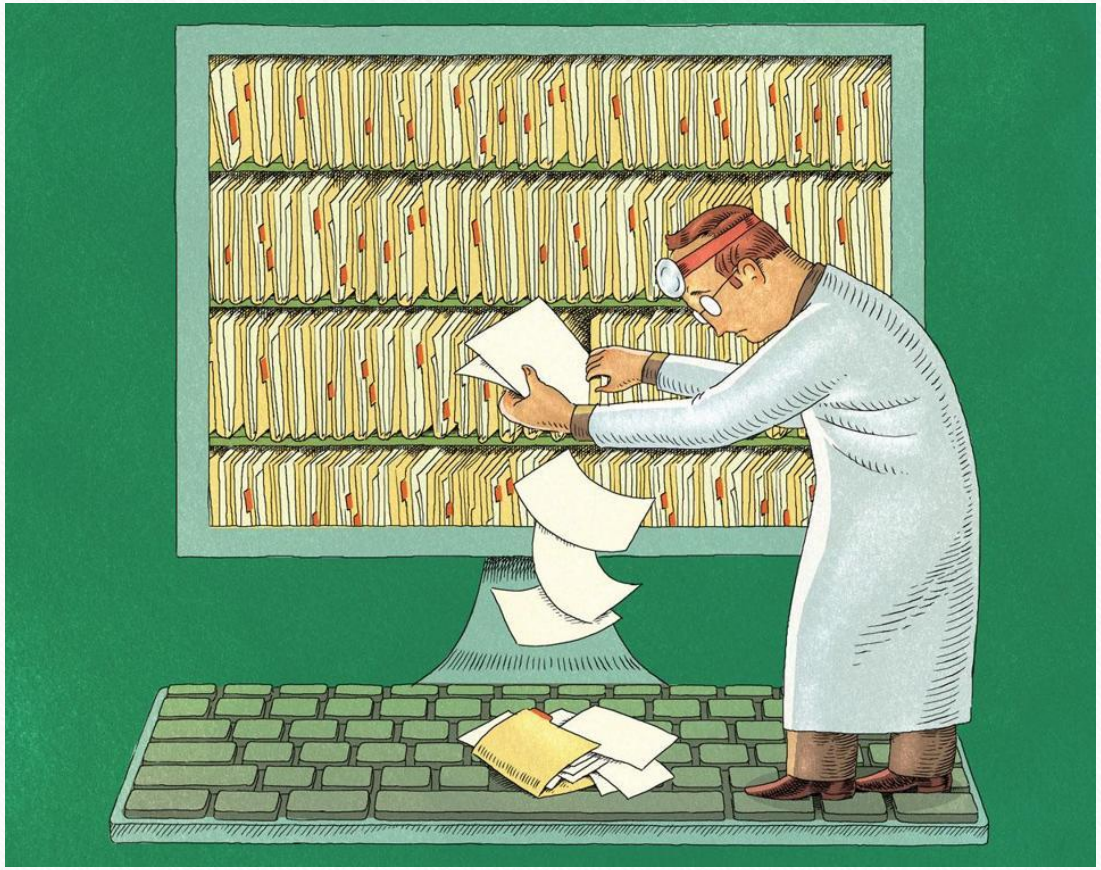
The Physician Point of View

- I see 20 patients per day, spend 10 minutes with each, don't have enough time.
- My patients are becoming multi-morbid, more and more data…
- I hate the EMR, I spend too much time on it and it's hard to find information.
- I can not really track my patient compliance.
- Patients demand a lot, they may sue me (and win…)
- Don't even think about additional information from sensors, genetics, etc. It's already too much for me…

The Patient Point of View

- I feel that the physician looks at the computer and does not really listen to me.
- I am lost and confused. For every disease there is a specialist and they don't seem to talk with each other.
- The physician does not have enough time to explain to me what should I do to improve my condition.
- The Internet and patients group provide me with a lot of information, but what is the best treatment for ME?

Information Chaos



Barriers for Patient Empowerment

- Patient-Physician Information Gap
- Lack of Patient Proactive Role
- Lack of Support for Multi-morbidities
- Integration of patient's platforms (e.g. mHealth) with the EMR

Patient-Physician Information Gap

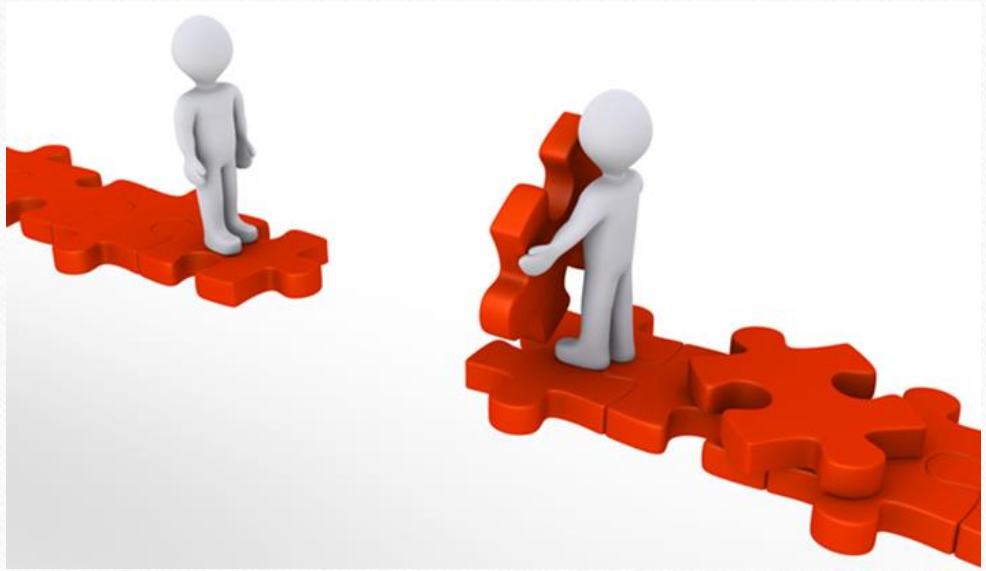
- Physician faces with a formidable task of integrating the clinical story from many sources in a short time.
- Patients have limited access to medical data.
- Can patient transform the data into an easy to use knowledge?

Patient-Physician Information Gap

- Do doctors provide patients with an overall (and concise) view of disease progression? Multi-morbidities?
- Displaying key indicators in cool graphs is not enough!
- Patients are left with a partial picture and lack the context ("why-do-I-have-to-do-this?"), resulting in
  - Lack of motivation
  - Compliance problems

Patient-Physician Information Gap

- Can the physician and the patient really talk?
- Do they have a common language?
- Can the patient literally "take home" the message?

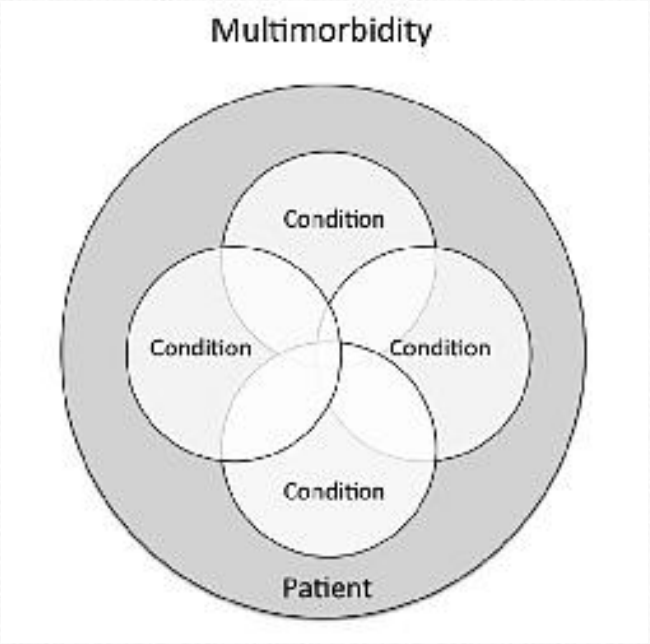


Lack of Patient Proactive Role

- Patients are left with the task of managing themselves.
- But are they involved in crafting the treatment plan?
- Do they understand:
  - the reasoning behind the treatment plan?
  - the effect a successful implementation of the plan will have on their health?
- Reducing the instructions to a series of tasks and reminders is sufficient?

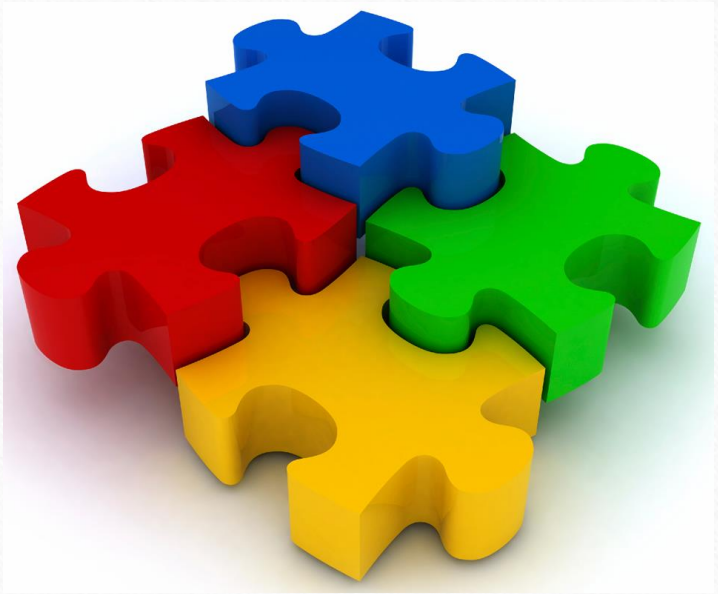
Lack of Support for Multi-morbidities

- Multi-morbidity is the new norm!
- Make the complex treatment plan even more complex
  - Conflicting goals
  - Conflicting treatments
- Applications support multi-morbidity?



Integration of mHealth and EMR

- Data gathered by mHealth applications is often not integrated with the patient's EMR medical history.
- Physician cannot access it if not integrated.



Data Use and Health Analytics

- Increase in life expectancy and in the prevalence of chronic diseases & multi-morbidities means increasing number of interactions with healthcare providers and increase of data generated.
- EHR data of a single patient include Petabytes of data (2^{50}B).
- Personalized medicine and specifically the relatively new omics-data may result in Exabytes (2^{60} B) of data (related to a single patient).
- Evidence-based medicine requires analysis of information generated from as many patients as possible. If we consider only 1/10 of humanity (roughly 10^9 people), the amount of data to be processed is in the order of thousands of Yottabytes (10^{24} B).

Data Use and Health Analytics

- Until recently, algorithms and infrastructure required to process these amounts of unstructured data were not in-par with this formidable task.
- The increase in processing power coupled with developments in AI (e.g. NLP and DL) make the vision of machine-generated personalized guidance, as well as population level analysis, feasible and real.
- IBM Watson can serve as an illustration to the new capabilities that stem from the improved hardware infrastructure and the new computational methods and algorithms.

Thank You

Questions