

Decision Support Systems Based on Artificial Intelligence For Doctors and Patients



Cary Oberije, PhD

The D-lab, dept. of Precision Medicine

CERN Workshop, Geneva 2019

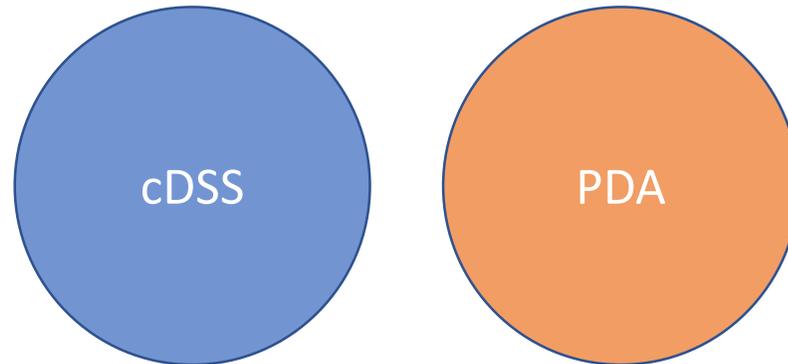
Introduction

- ✓ Background
- ✓ DSS for doctors and patients
- ✓ Shared Decision Making
- ✓ My story
- ✓ Artificial Intelligence and DSS
- ✓ Conclusions

Background Decision Support Systems

Target users

Requirements for doctors and patients have only limited overlap
Tools are seldomly used by both

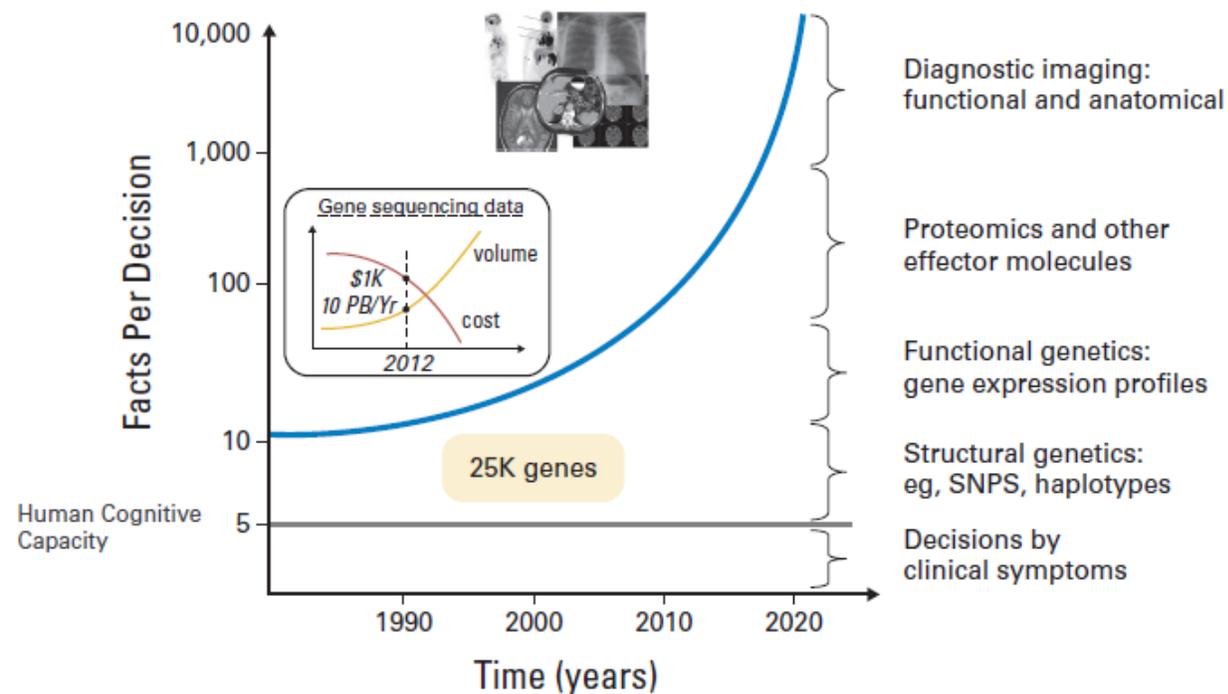


- Provide information
- Intelligently filtered
- At appropriate times
- To improve health care

DSS for Doctors and health care providers

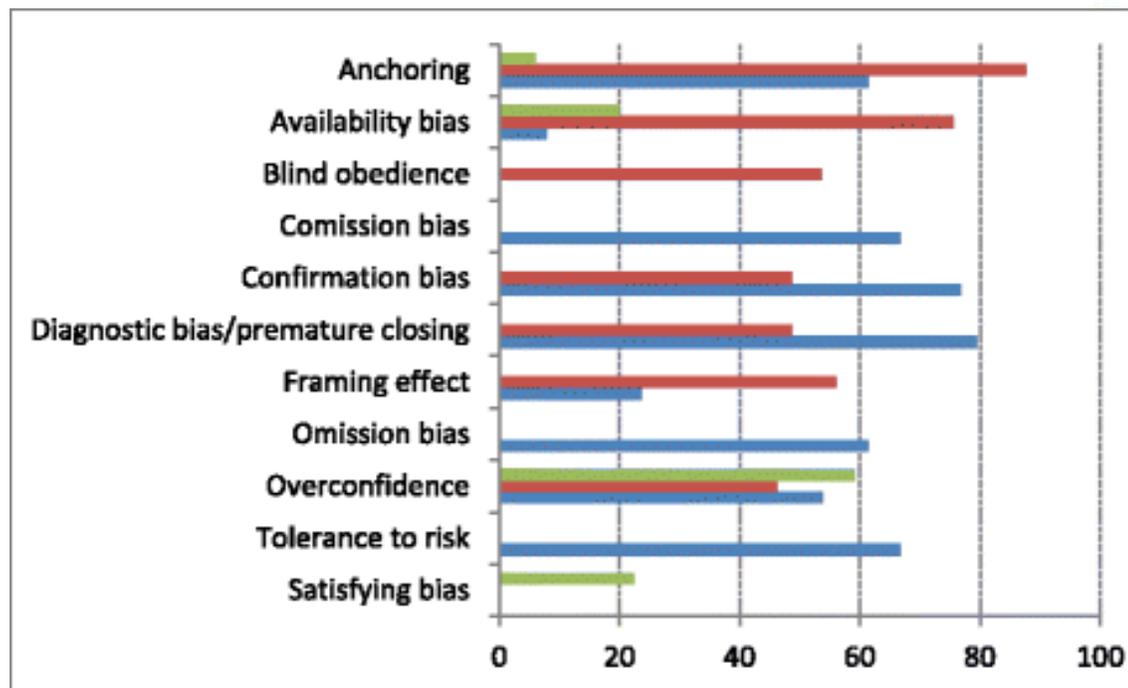
A tool to assist clinical decision making

- Increasing amount of diagnostic/prognostic information
- Increasing amount of treatment options



Optimal diagnosis /disease classification / treatment choice for an individual patient?

DSS for Doctors and HCP: Clinical Decision Making



Doctors are humans too.....



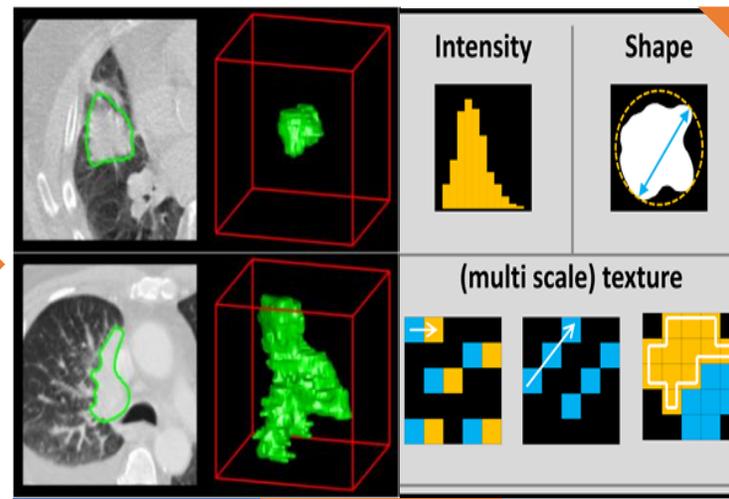
DSS for doctors: Not a replacement!

Skipping the boring (and time-consuming) step



Humans are apes

There is only so much information we can hold at the same time

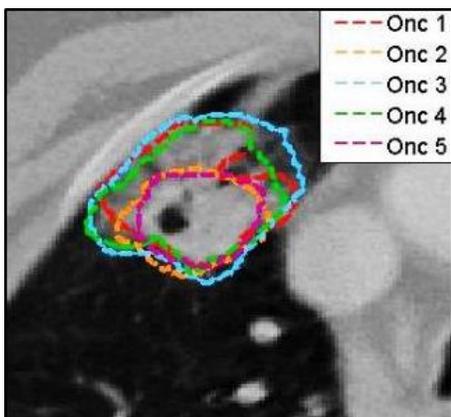


Quantitative Image Analysis

Will disrupt current interpretative, subjective imaging

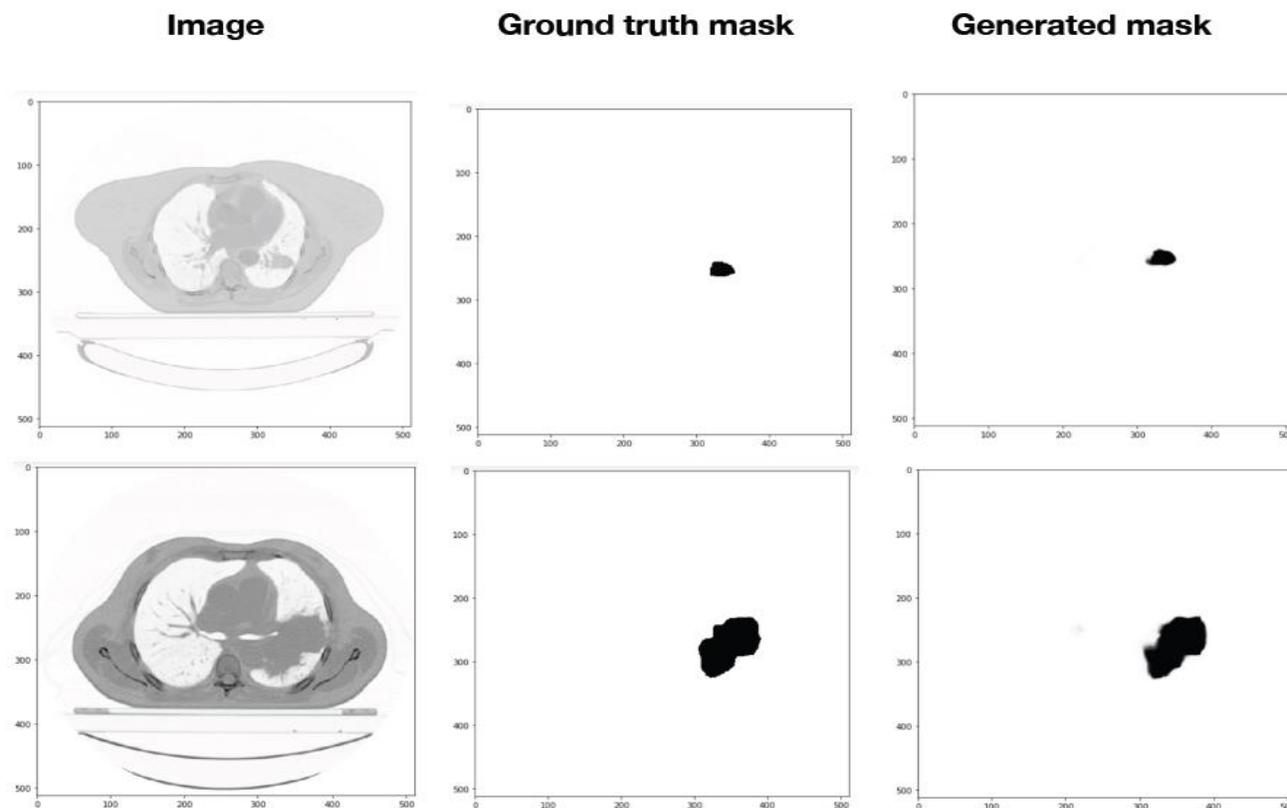
DSS for doctors: Not a replacement!

Decreasing interobserver variability



Tao et al. Radiother Oncol 2015;
Tappeiner et al Int J Comput Assist
Radiol Surg 2019

Ongoing project at The D-lab: lungcancer delineation



DSS for Patients: Patient Decision Aid (PDA)

A tool to facilitate patient participation

Time trend

< year 2000: 50% of studies showed majority want to participate

> year 2000: 71% of studies!



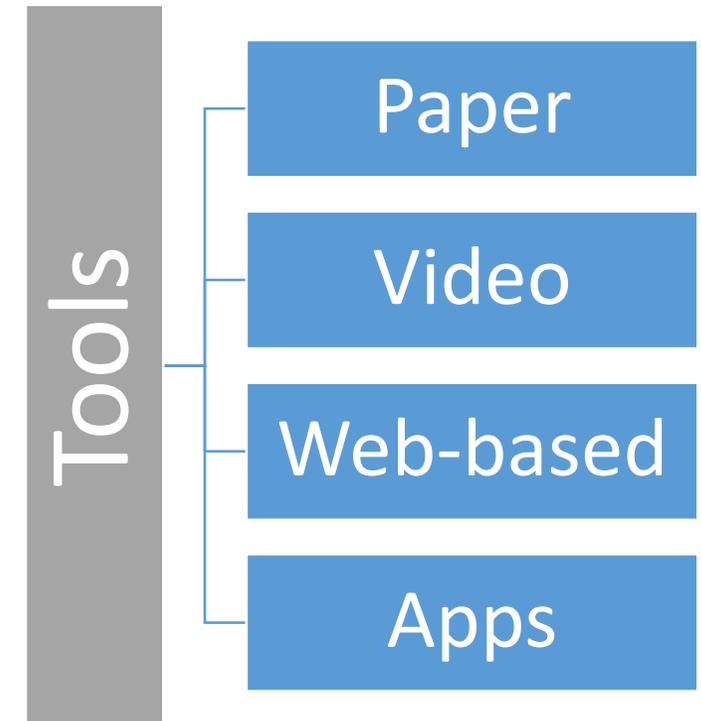
85% of studies if it concerns cancer patients

- Information about the decision
- Information about options and outcomes
- Clarify preferences and values

DSS for Patients: Definition of Patient Decision Aids

Tools that help patients become involved in shared decision making by clarifying the treatment or medical decision that needs to be taken.

These tools provide information about the options and outcomes, and clarify personal values.



Shared Decision Making

Patient participation in the process

“An interactive process during which patients and practitioners collaborate in choosing healthcare”



Légaré F, Stacey D, Brière N et al. A conceptual framework for interprofessional shared decision making in home care: Protocol for a feasibility study. BMC Health Serv Res. 2011;11:23

Example PDA for patients: ongoing project lung cancer

The screenshot displays a web-based Patient Decision Aid (PDA) interface. In the top right corner, there are links for 'Home' and 'Logout'. The main content area is titled 'Welcome' and contains the following text: 'You have been diagnosed with stage I-II non-small cell lung cancer.' Below this, a bulleted list provides information: 'This decision aid will provide information on the different treatment options available for stage I-II non-small cell lung cancer. The decision aid helps and help you to think about what treatment might be preferred by you.' 'The tool will inform you about surgery, radiotherapy, chemotherapy and immunotherapy.' 'Press the Next Page button for an introduction on how to use this decision aid.' To the right of the text is a circular illustration of a doctor with a white beard and a stethoscope. At the bottom right, there is a 'Next Page >' button. On the left side, a vertical navigation menu includes: 'My Introduction' (highlighted with a blue border), 'My Treatment Options', 'My Comparison', 'My Knowledge', 'My Preferences', 'My Results', and 'Dictionary'. The PDA logo, 'PDA Patient Decision Aid', and the text 'Stage I-II LUNG cancer' are located in the top left corner of the interface.

Example PDA for patients: ongoing project trial participation



- Introduction
- Trial Information
- Your Preferences
- Your Results
- Participating Centers

Funding

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733008



Welcome to ImmunoSABR Decision Aid

ImmunoSABR is a six-year research project funded by the European Commission's Horizon 2020: the EU Framework for Programme for Research and Innovation. It is a multi-centre phase II trial to test if the combination of high dose radiotherapy (Stereotactic Ablative Body Radiation = SABR) and L19-IL2 immunotherapy.

Please play the video below to have a comprehensive idea about this combination therapy.



[Go to Trial Information >](#)

Use of Patient Decision Aids

Positive effect on patients



**Cochrane
Library**

Cochrane Database of Systematic Reviews

Decision aids for people facing health treatment or screening decisions (Review)

Stacey D, Légaré F, Lewis K, Barry MJ, Bennett CL, Eden KB, Holmes-Rovner M, Llewellyn-Thomas H, Lyddiatt A, Thomson R, Trevena L

Level 1 evidence (review 2017)

- More knowledge
- Better understanding probabilities
- Increased confidence in decisions

PDA's: Barriers for implementation

No widespread adoption.....

Elwyn, 2013, BMC Med Inform Decis Mak



Reasons HCP do not refer patients to use Patient Decision Aids

- Lack of confidence in content
- Disruption established workflow
- Organizational passivity

Glenn & Urquhart, 2019, Curr Oncol

Remove the barriers?

Are we done if we solve it?



hurdles, do we achieve the goal of shared decision making?

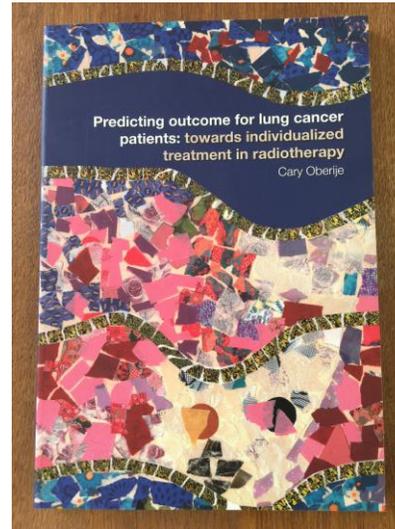
Knowing your options, harms and benefits.....

My story

Thesis defense



February 2011



July 2011

Towards individualized treatment.....

My story

Many choices to make

Breast conserving surgery vs mastectomy

Book with photo's

With or without reconstruction

Trial participation or not

Brochure and CD

Chemotherapy: yes/no

Hormonal therapy yes/no

Conversation with doctors and nurses

Webbased tool: Adjuvant online

Breast surgeon
Plastic surgeon
Radiation oncologist
Medical oncologist
Family & Friends
Patients like me

Neo-adjuvant or adjuvant chemotherapy

No tool

Radiotherapy: Necessary?

No tool

Second Opinion

Radiation scheme: conventional or integrated boost

No tool

My story

Still choices to make, after all these years.....

2017 change in guideline: Tamoxifen 10 instead of 5 years

Search Pubmed for breast cancer and Tamoxifen: 16,777 hits
Only 2017: 511

Evidence RCT's benefit: HR DFS 0.86

Meta-analysis Hellemond et al, Curr Treat Options Oncol, 2018

Common side effects

- Fatigue
 - Hot flushes and sweats
 - Vaginal changes
 - Leg cramps
 - Eye problems
 - Skin rash
 - Feeling sick
 - Hair thinning
- + occasional effects
+ rare effects

My story

Number for 1 year distant recurrence

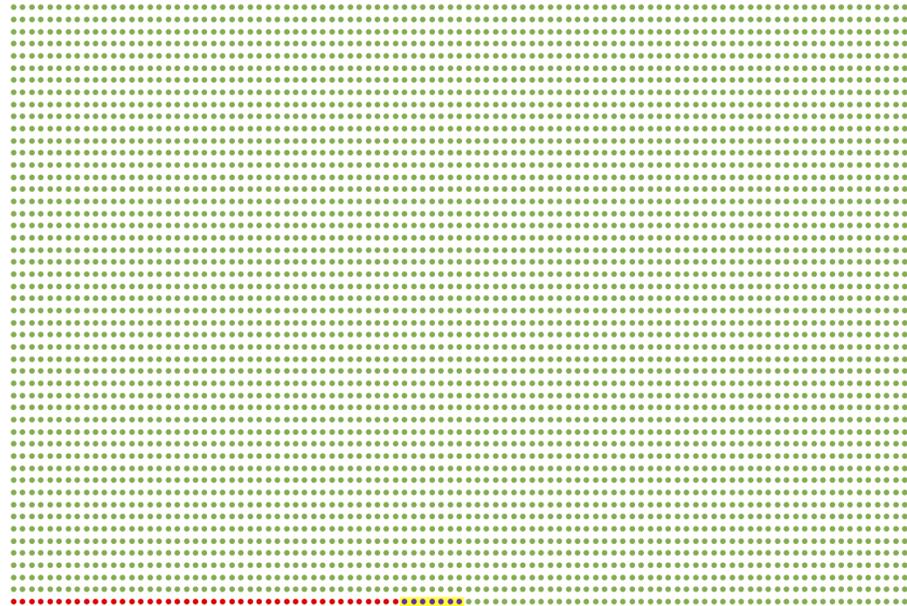
Distant mets: 13% in 15 year

Together with other Recurrences: 22% in 15 year

Pan et al, N Eng J Med, 2017

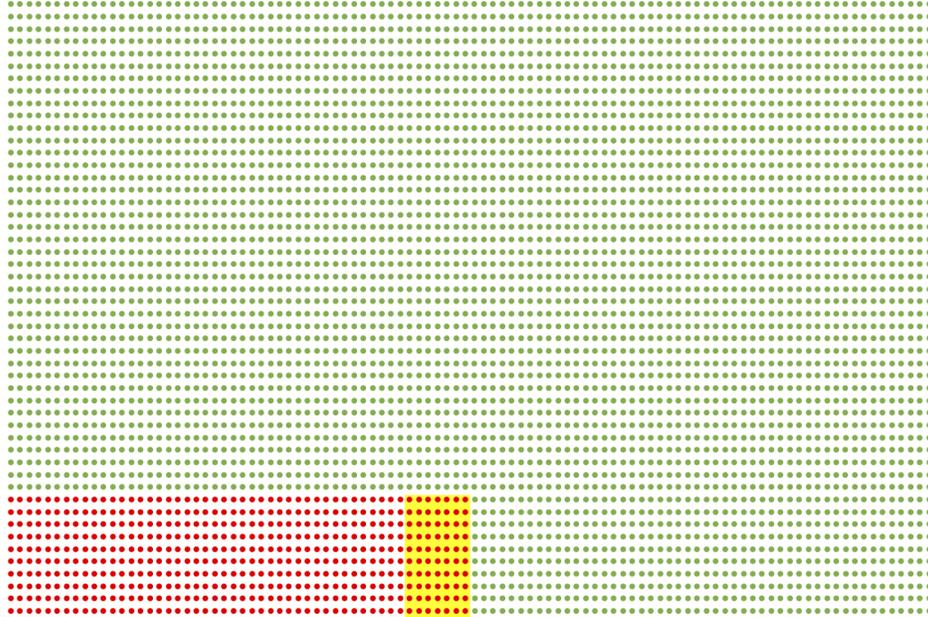
Absolute risk: distant recurrence rate 1% / year

5 years of Tamoxifen 50 out of 5,000
10 years of Tamoxifen 43 out of 5,000



My story

And here are the numbers for 10 year distant metastasis free survival



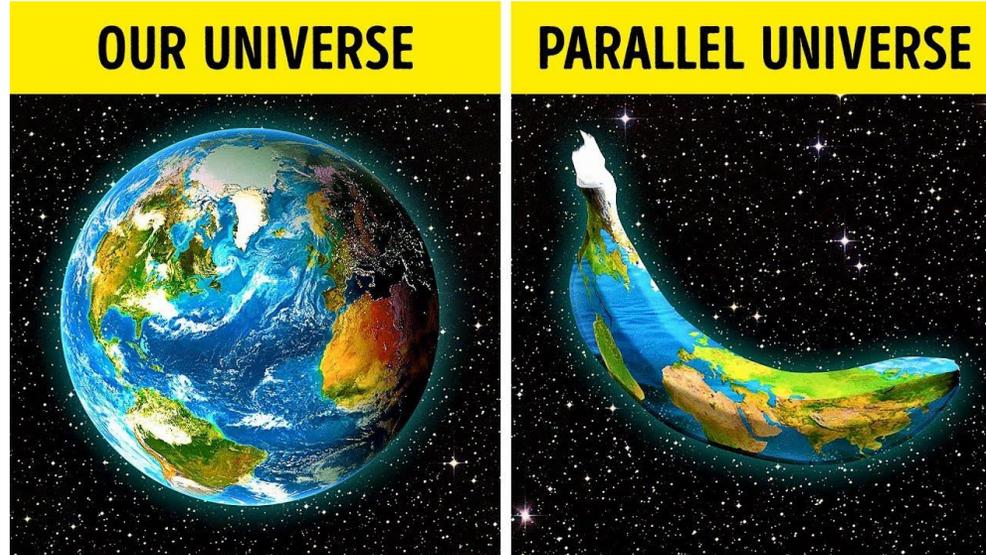
But $HR=0.86$ is a point estimate
Confidence interval?

These trials started years before I was diagnosed

I want personalized information, beyond stage or age!

AI and Precision Medicine: predictive modeling

Treatment benefit??



Treatment A



Outcome



Treatment B



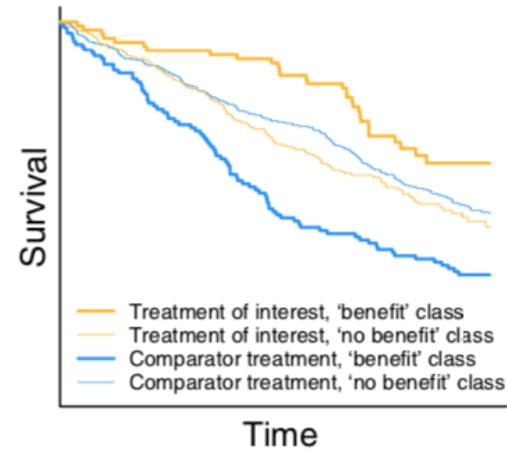
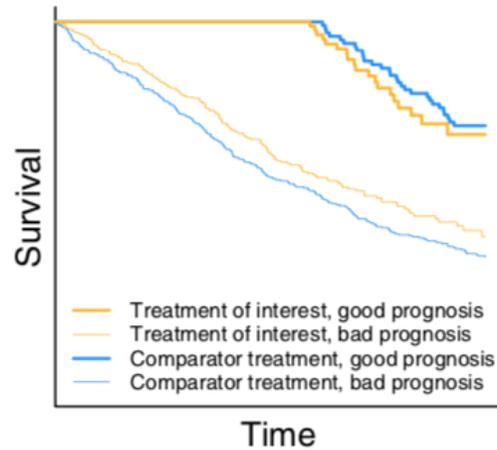
Outcome



Comparison

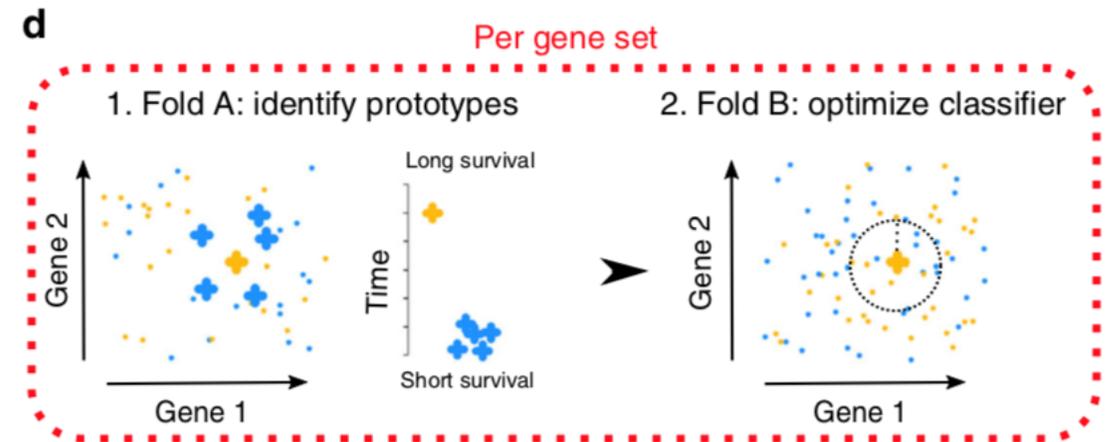


AI and Precision Medicine: Example STL

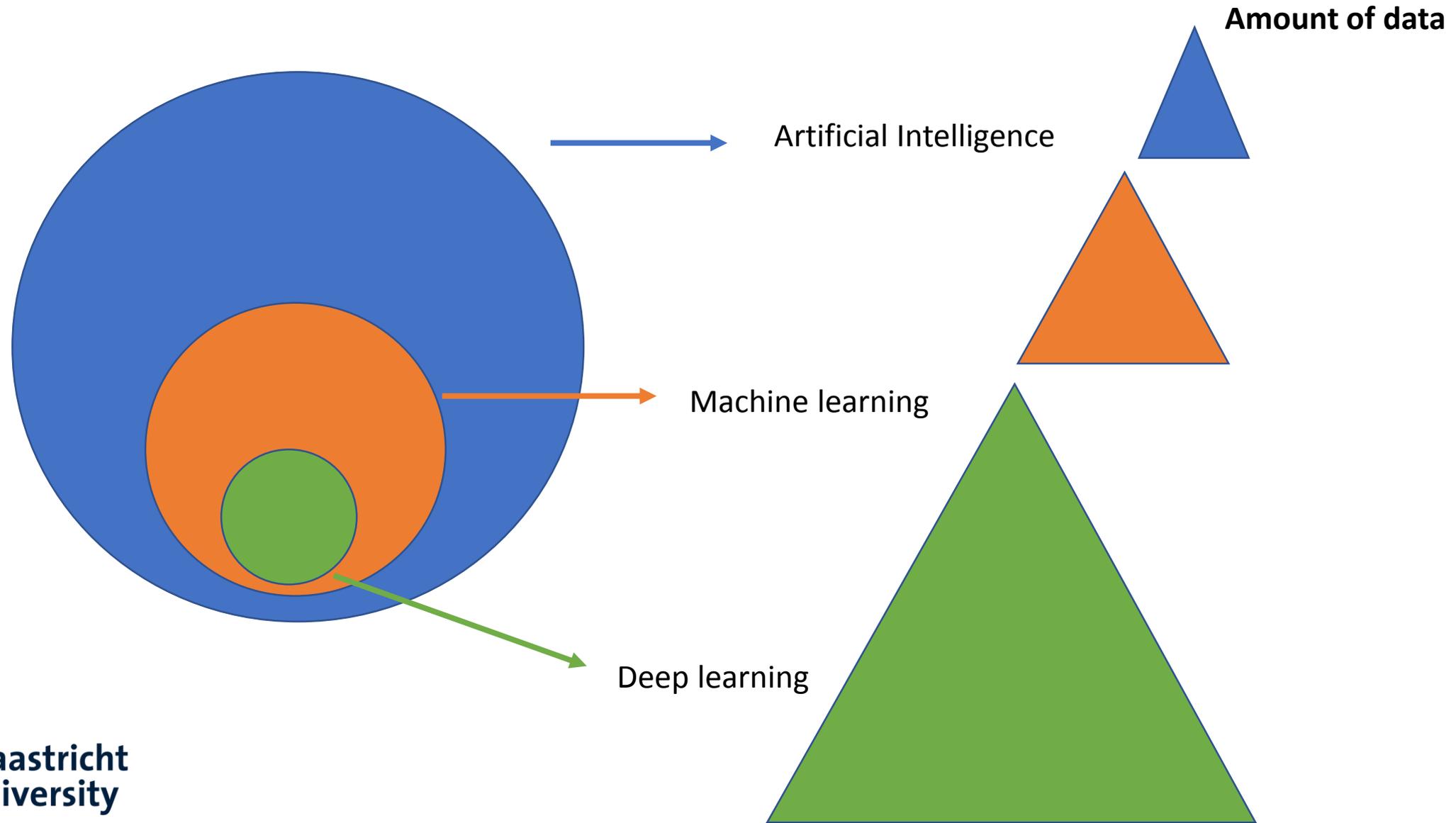


Modeling approach
Simulated treatment learning

Development of new methods is needed!



AI and DSS: Amount of data



AI and DSS: How can we get big data?

Option 1: Distributed learning



Radiotherapy and Oncology 121 (2016) 459–467



ELSEVIER

Contents lists available at [ScienceDirect](#)

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com



Distributed learning

Distributed learning: Developing a predictive model based on data from multiple hospitals without data leaving the hospital – A real life proof of concept



Arthur Jochems^{a,*}, Timo M. Deist^{a,b,1}, Johan van Soest^{a,b}, Michael Eble^c, Paul Bulens^d, Philippe Coucke^e, Wim Dries^f, Philippe Lambin^{a,b,1}, Andre Dekker^{a,1}

^a Department of Radiation Oncology (MAASTRO Clinic), Maastricht; ^b GROW – School for Oncology and Developmental Biology, Maastricht University Medical Centre, The Netherlands; ^c Klinik für Strahlentherapie (University clinic Aachen), Germany; ^d Department of Radiation Oncology (Jessa Hospital), Hasselt, The Netherlands; ^e Departement de Physique Medicale (CHU de Liège), Belgium; and ^f Catharina-Hospital Eindhoven, The Netherlands



Connect the data from multiple hospitals via **ontology mapping**, without data leaving each hospital.



Send the model training applications to the different hospitals, and integrate results at the central location.

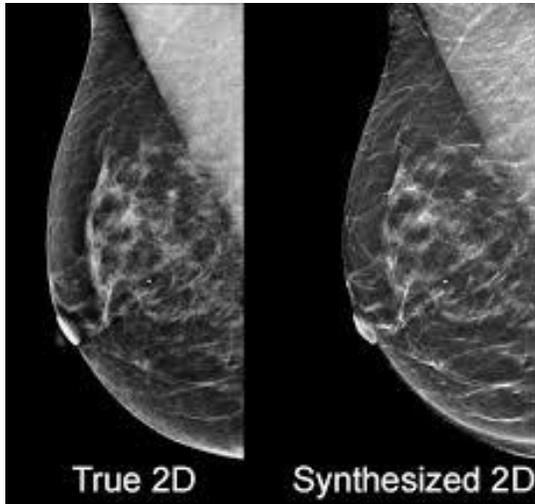


Larger databases will allow for a faster translation of radiomics decision support systems into the clinical environment.

AI and DSS: How can we get big data?

Option 2: Synthetic data

Yes, we can create realistic images.....



Elangovan et al, 2017, Phys Med Biol



Artificial Intelligence in Medicine

Volume 75, January 2017, Pages 51-63



Handling limited datasets with neural networks in medical applications: A small-data approach

Torgyn Shaikhina, Natalia A. Khovanova  

[Show more](#)

<https://doi.org/10.1016/j.artmed.2016.12.003>

[Get rights and content](#)

Under a Creative Commons [license](#) [open access](#)

Bone strength estimation in severe osteoarthritis

.....and we can use them for modeling!!!

AI and DSS: How can we get big data?

Option 3: Collective intelligence / Crowdsourcing

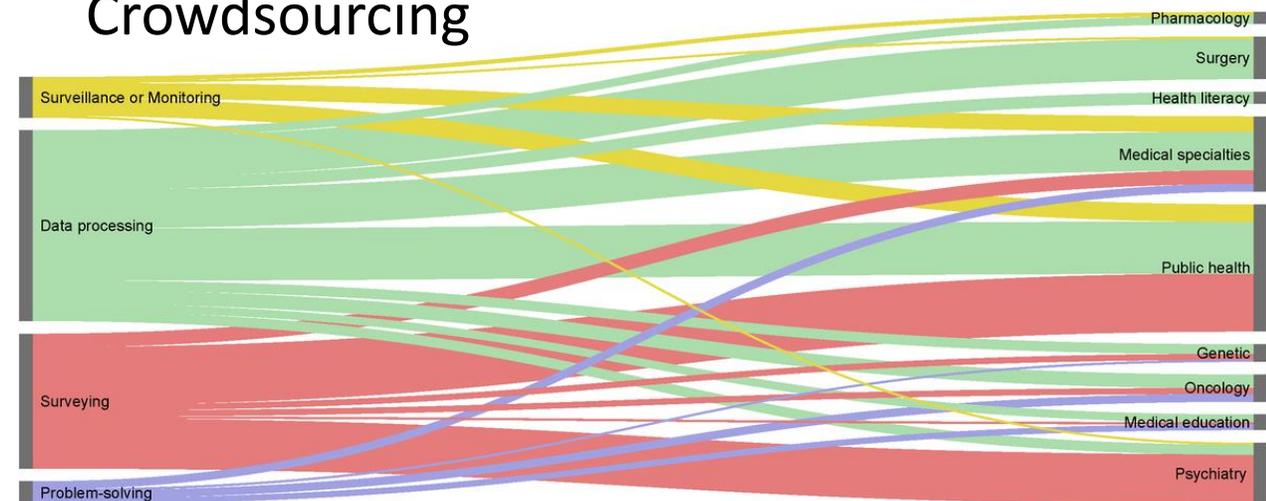
Collective Intelligence Meets Medical Decision-Making: The Collective Outperforms the Best Radiologist

Max Wolf , Jens Krause, Patricia A. Carney, Andy Bogart, Ralf H. J. M. Kurvers

Published: August 12, 2015 • <https://doi.org/10.1371/journal.pone.0134269>

patientslikeme[®]

Crowdsourcing



Crequit et al, 2018, JMIR

AI and DSS: Methodology

We still need to learn a lot about deep learning.....

- Many tuning parameters algorithms
- Possible bias of models
 - Choice of optimization
 - Biased data



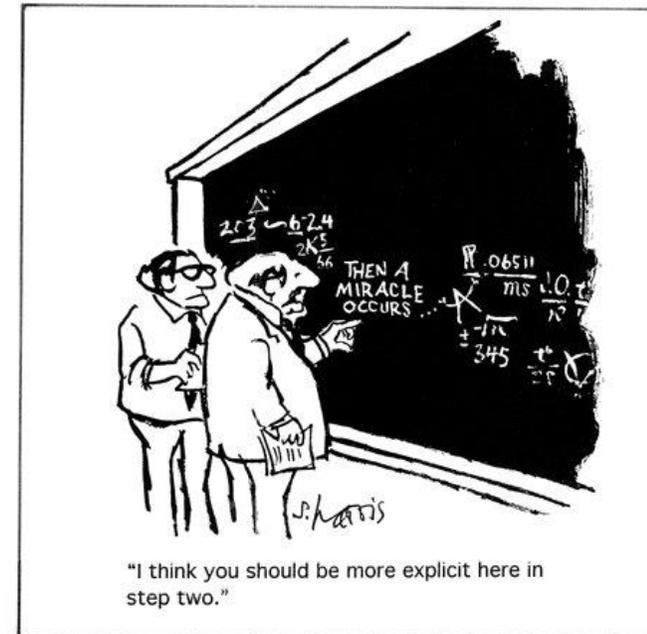
©marketoonist.com

AI and DSS: the black box debate

Improving doctor's and patient's understanding of DSS recommendation

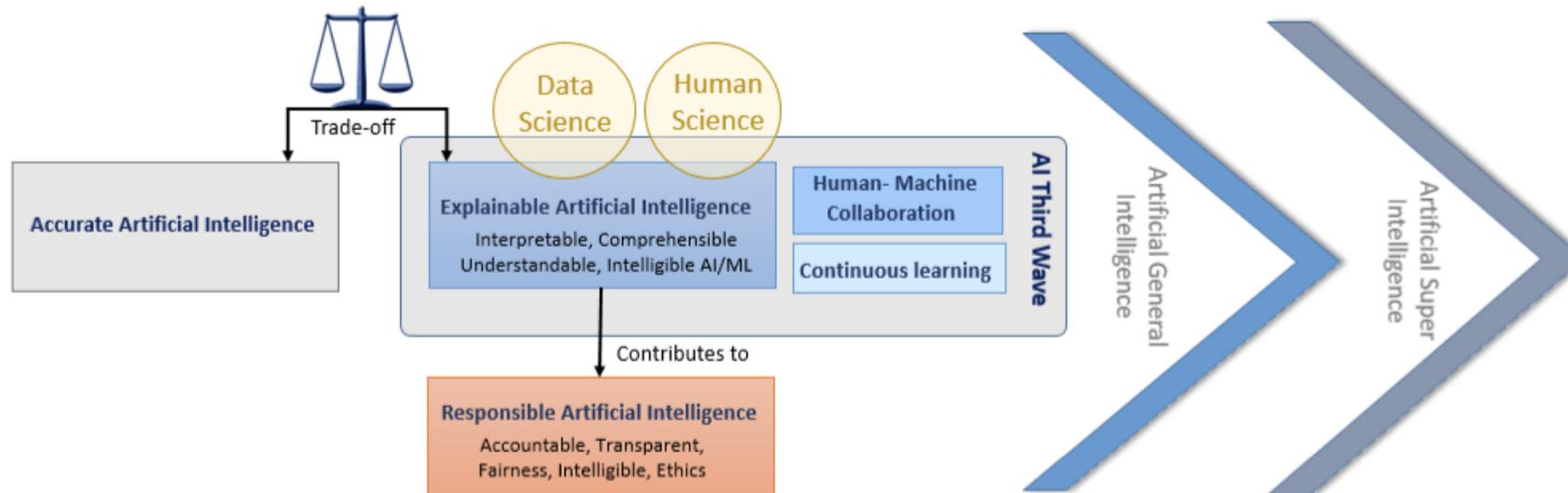
Imaging: visualize what the “deep learning” algorithm “sees”

Other data sources (clinical info, omics data): Indicate most important features used for decision
For example LIME algorithm



AI and DSS: the black box debate

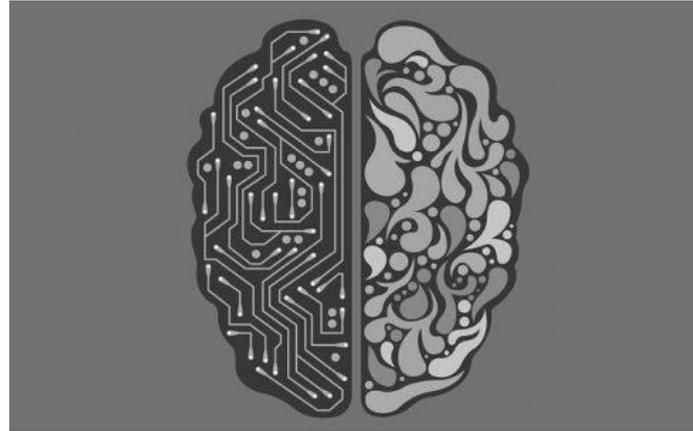
Peeking Inside the Black-Box: Explainable Artificial Intelligence (XAI)



AI and DSS: the black box debate

Is explainability an absolute requirement?

High dimensional spaces
Complex problems
Millions of calculations



Let's not forget that the human brain is very much a black box

AI and DSS: future partners for life

Intelligent Decision Support Systems are already developed and are here to stay

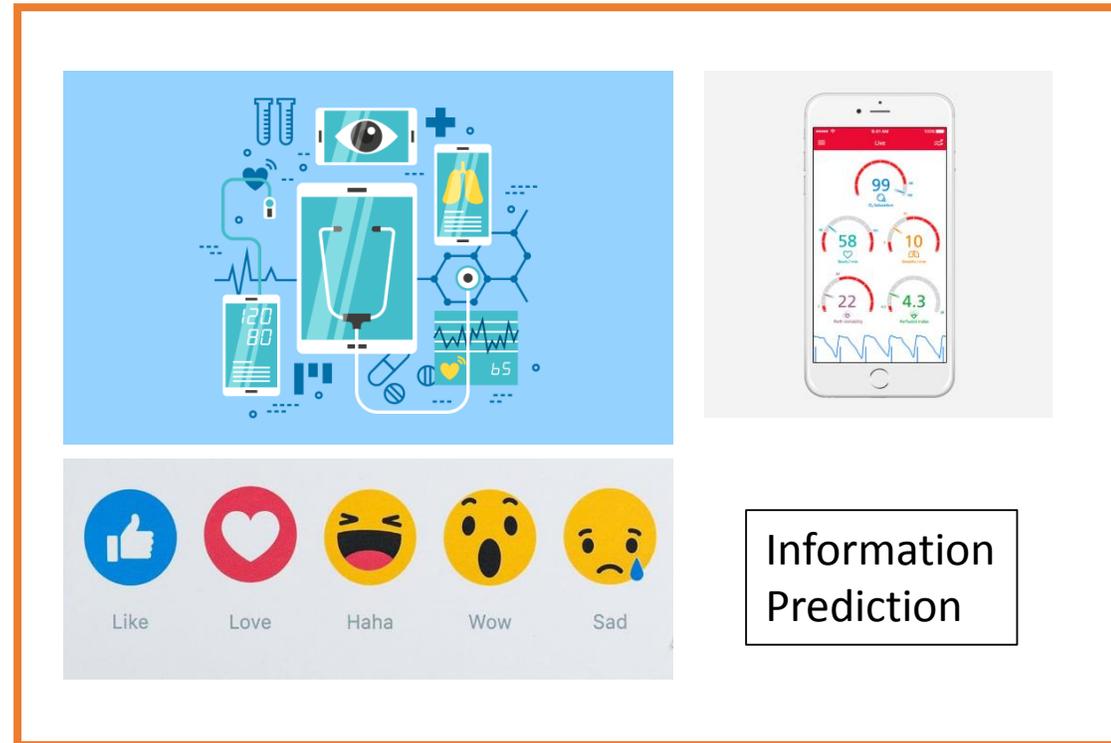


Company	FDA Approval	Indication
Apple	September 2018	Atrial fibrillation detection
Aidoc	August 2018	CT brain bleed diagnosis
iCAD	August 2018	Breast density via mammography
Zebra Medical	July 2018	Coronary calcium scoring
Bay Labs	June 2018	Echocardiogram EF determination
Neural Analytics	May 2018	Device for paramedic stroke diagnosis
IDx	April 2018	Diabetic retinopathy diagnosis
Icometrix	April 2018	MRI brain interpretation
Imagen	March 2018	X-ray wrist fracture diagnosis
Viz.ai	February 2018	CT stroke diagnosis
Arterys	February 2018	Liver and lung cancer (MRI, CT) diagnosis
MaxQ-AI	January 2018	CT brain bleed diagnosis
Alivecor	November 2017	Atrial fibrillation detection via Apple Watch
Arterys	January 2017	MRI heart interpretation

Next step: AI and individualized patient decision aids

Integration of personal and clinical information in a PDA

→ **iPDA**



Conclusions

- DSSs and PDAs help doctors and patients
- Artificial Intelligence can improve current DSS
- Main challenges: insufficient data, methodology and interpretability
- These challenges can and will be solved
- Artificial Intelligence and big data: important for precision medicine

Thank you for your attention

Questions?

c.oberije@maastrichtuniversity.nl

Visit us: www.TheDLab.info

Use of patient decision aids

Study breast cancer patients:
only 50% was asked about their preferences

Lee et al, 2012, J Am Coll Surg

No widespread adoption.....

Elwyn, 2013, BMC Med Inform Decis Mak