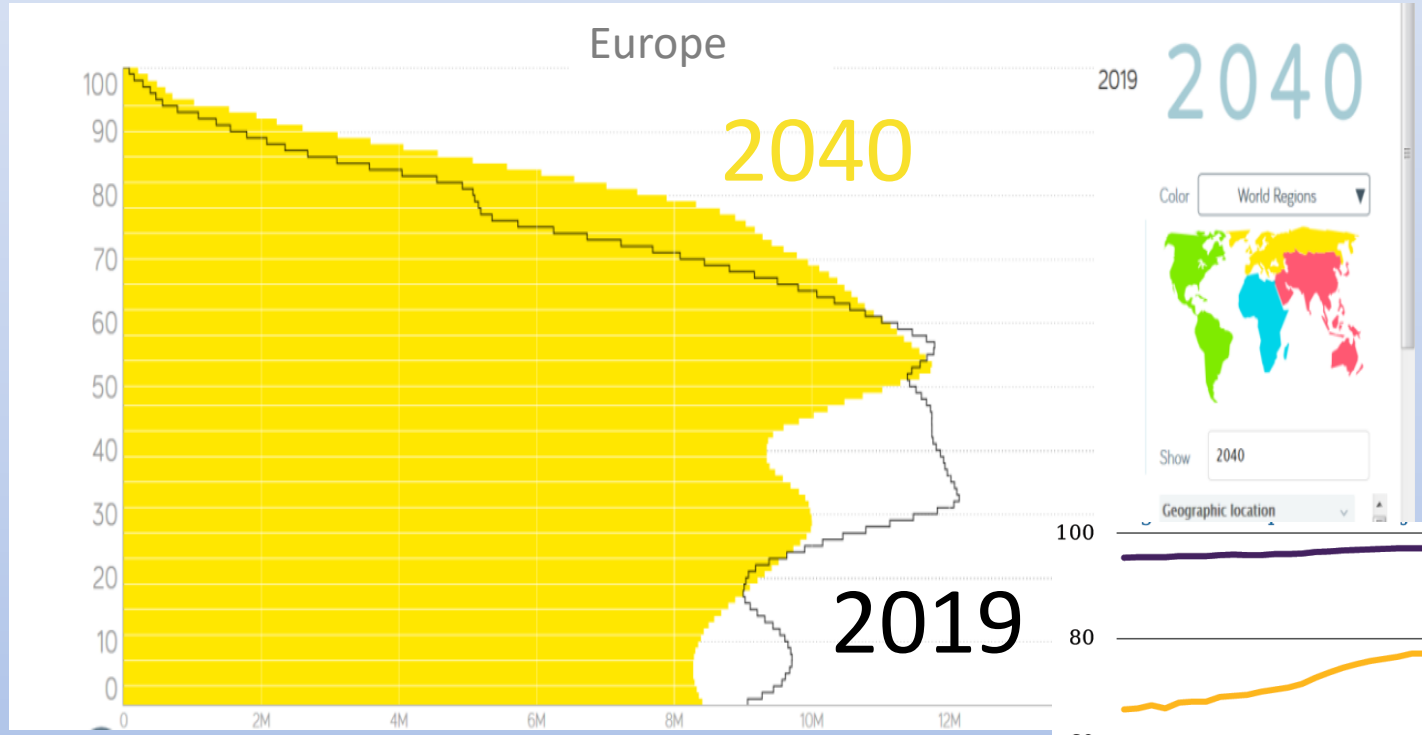
# The Future of Health Care

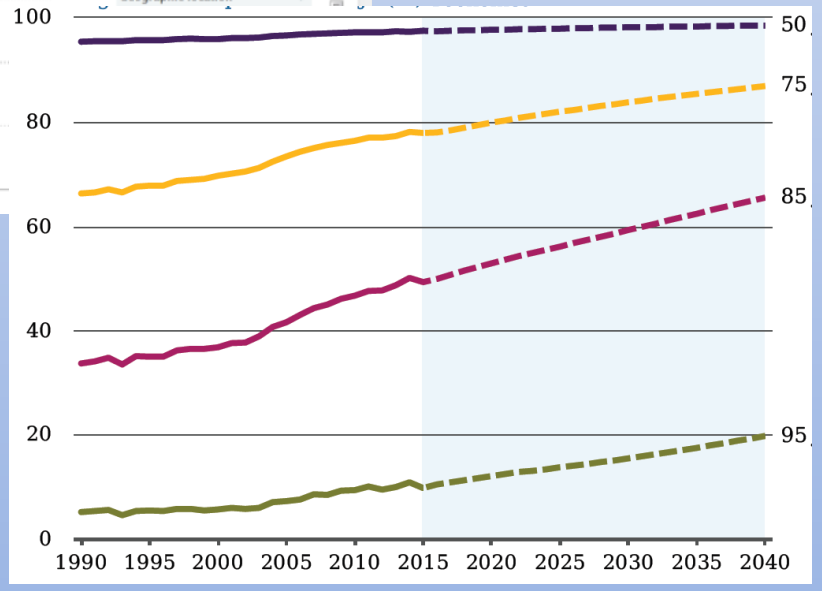
T Ruers
Head of the Division Surgical Oncology
Antoni van Leeuwenhoek Hospital
Amsterdam

# Population by age



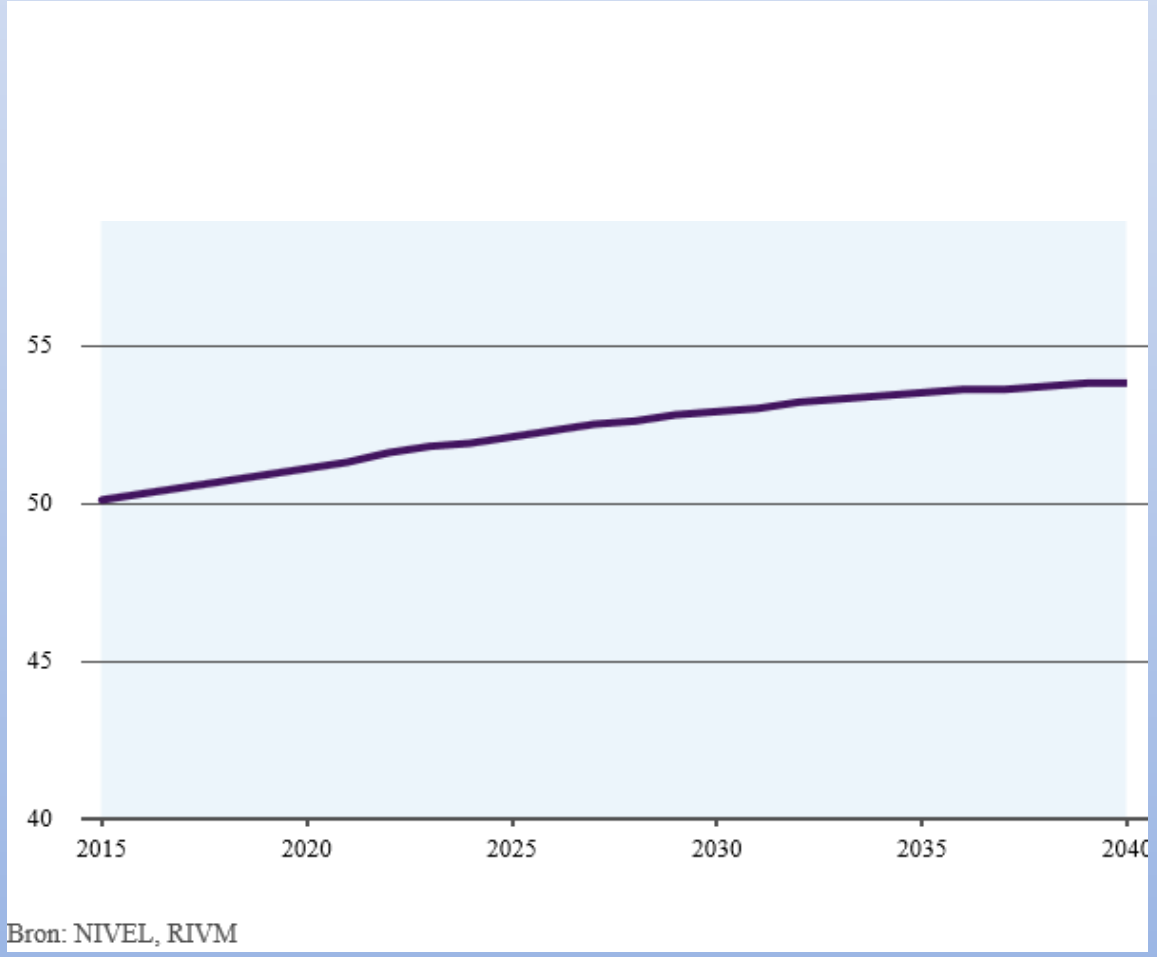






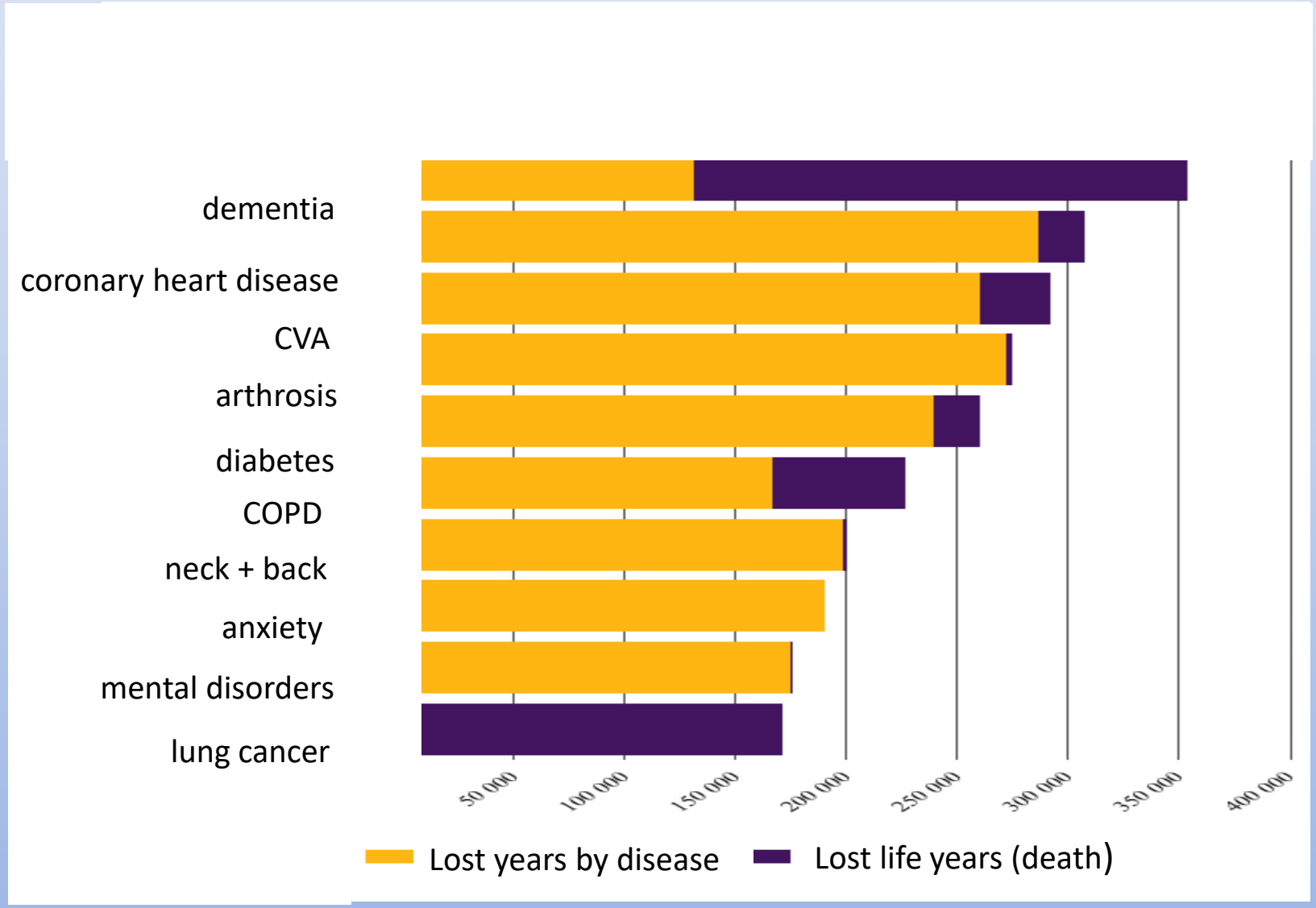

Gapminder.org, RIVM/NIVEL

# > 50% of people have at least 1 chronic disease



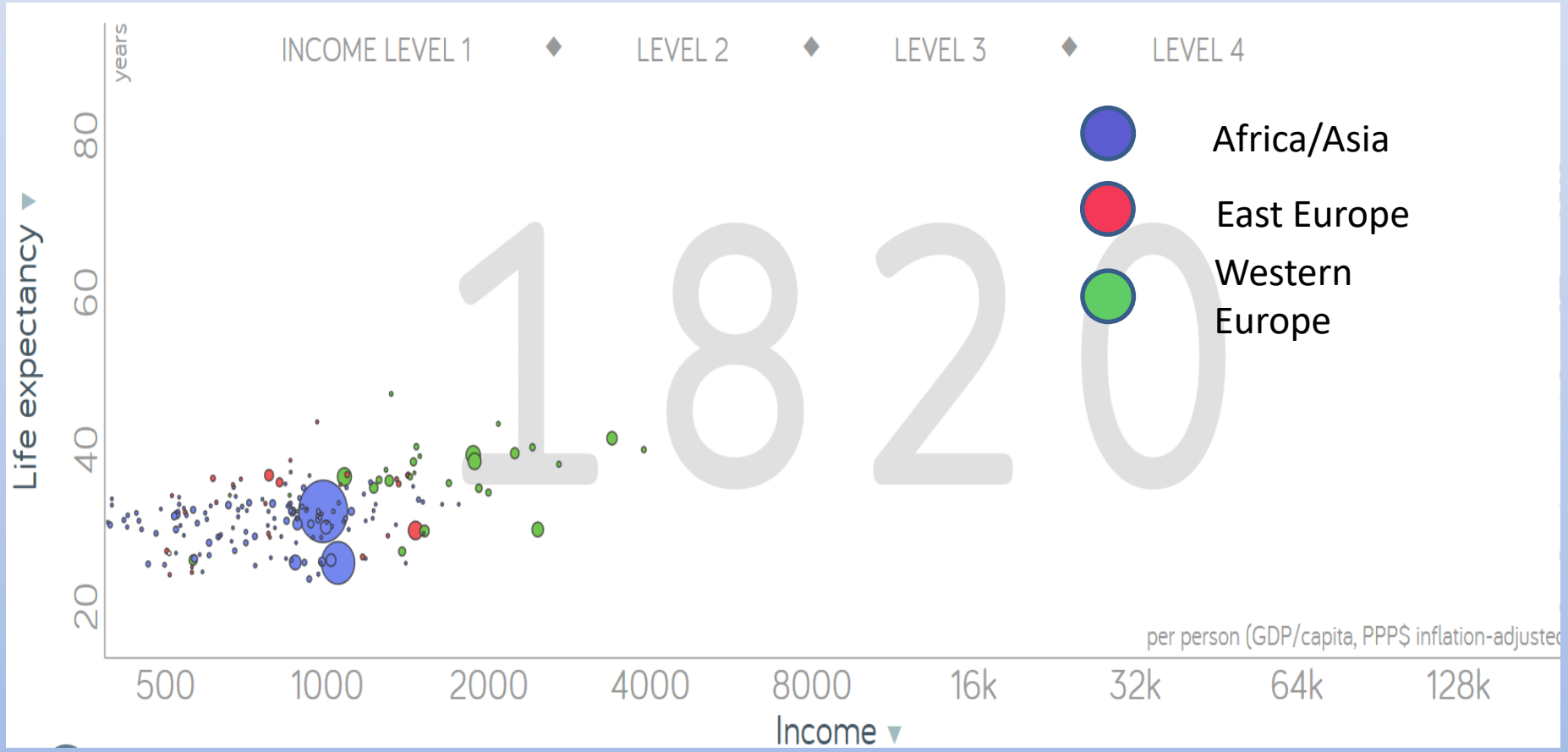

Source: NIVEL,RIVM

# Disability adjusted life years



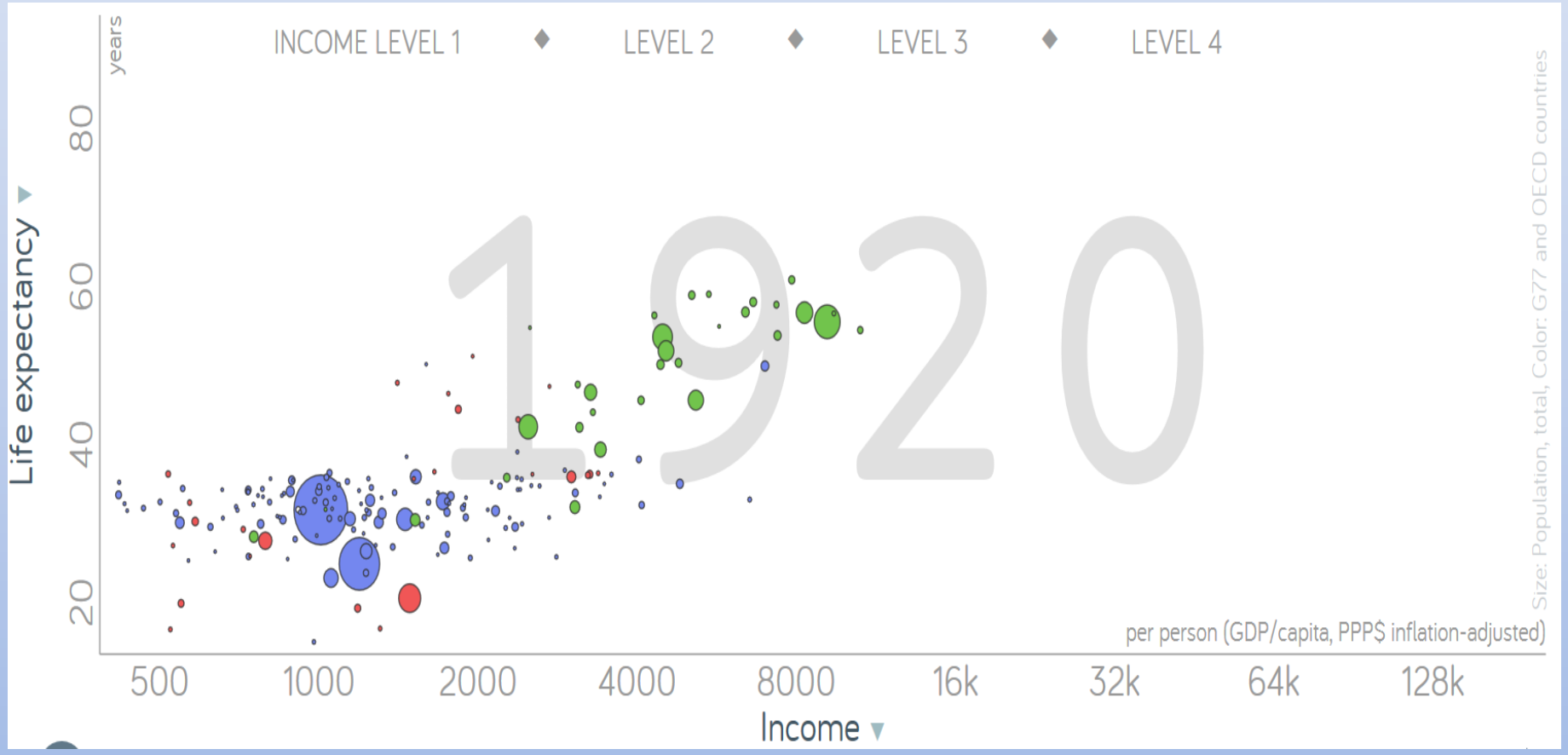

Source: NIVEL,RIVM

# Income – life expectancy



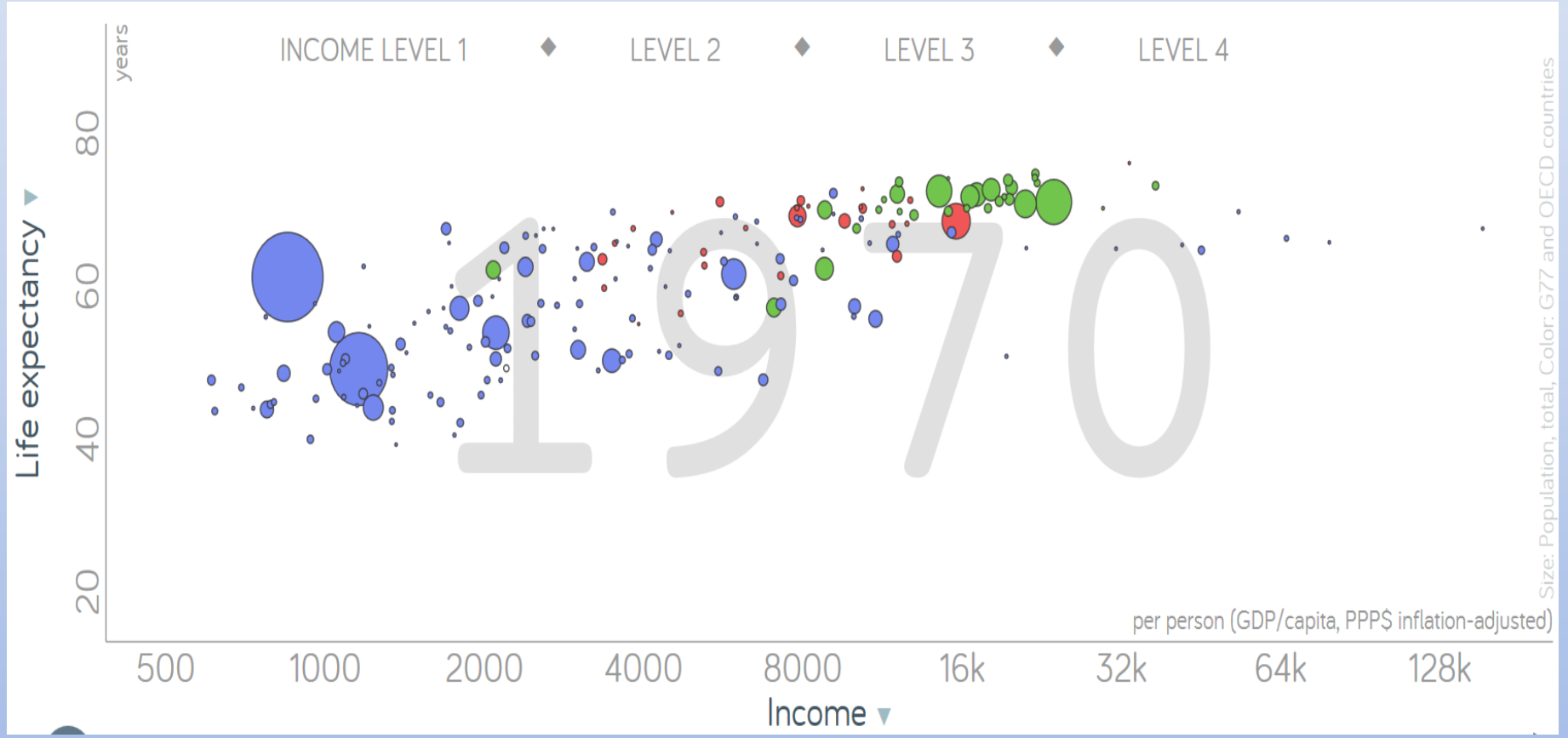

Gapminder.org

# Income – life expectancy



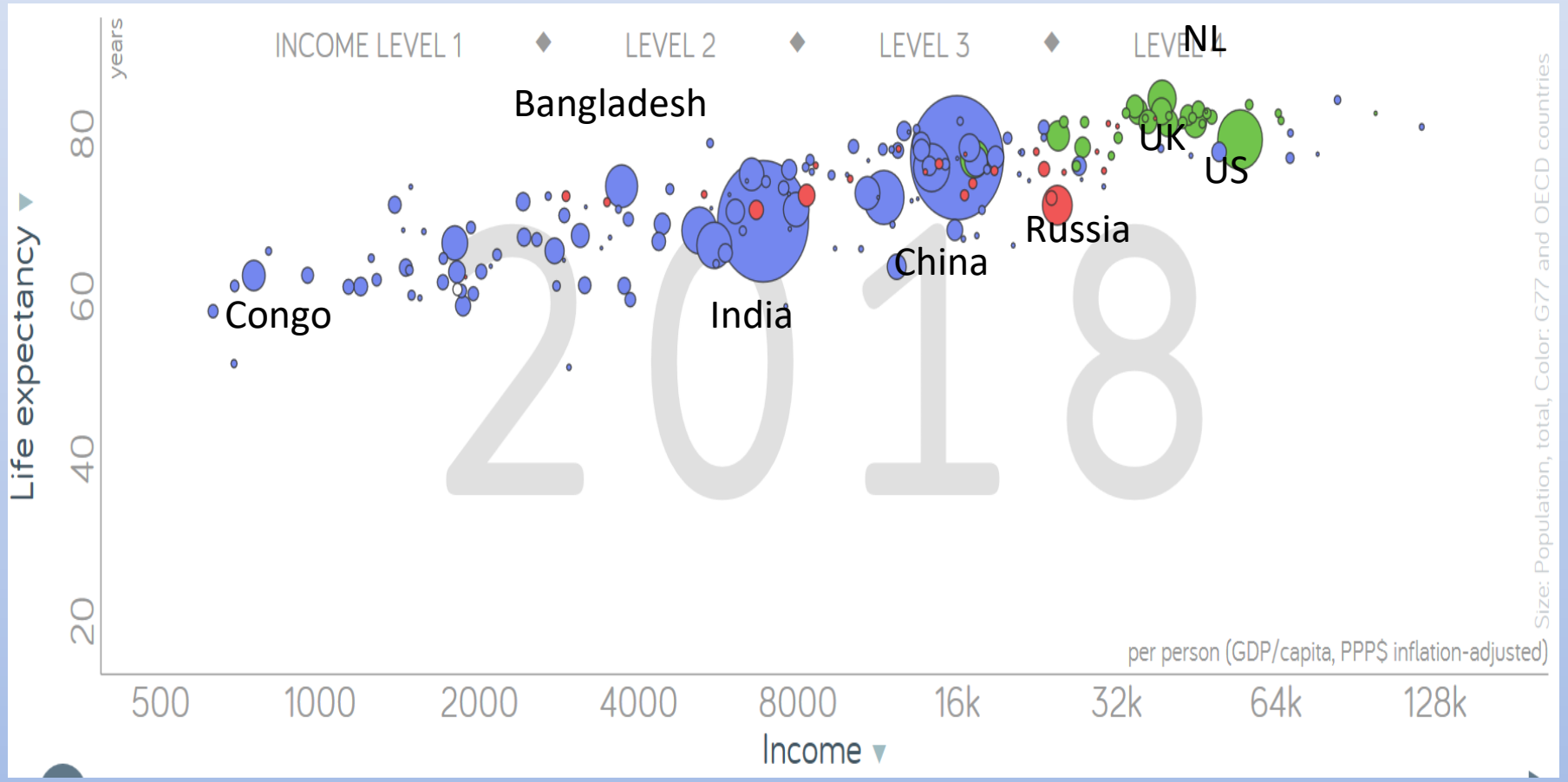

Gapminder.org

# Income – life expectancy



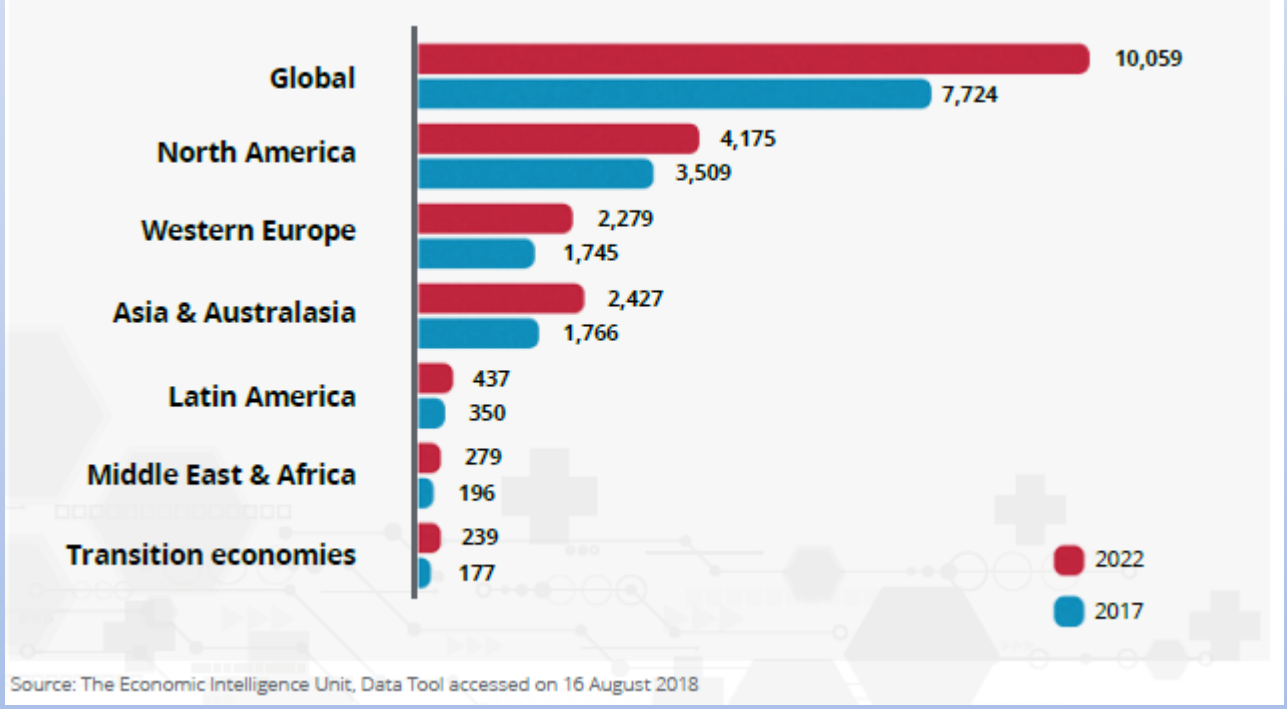

Gapminder.org

# Income – life expectancy

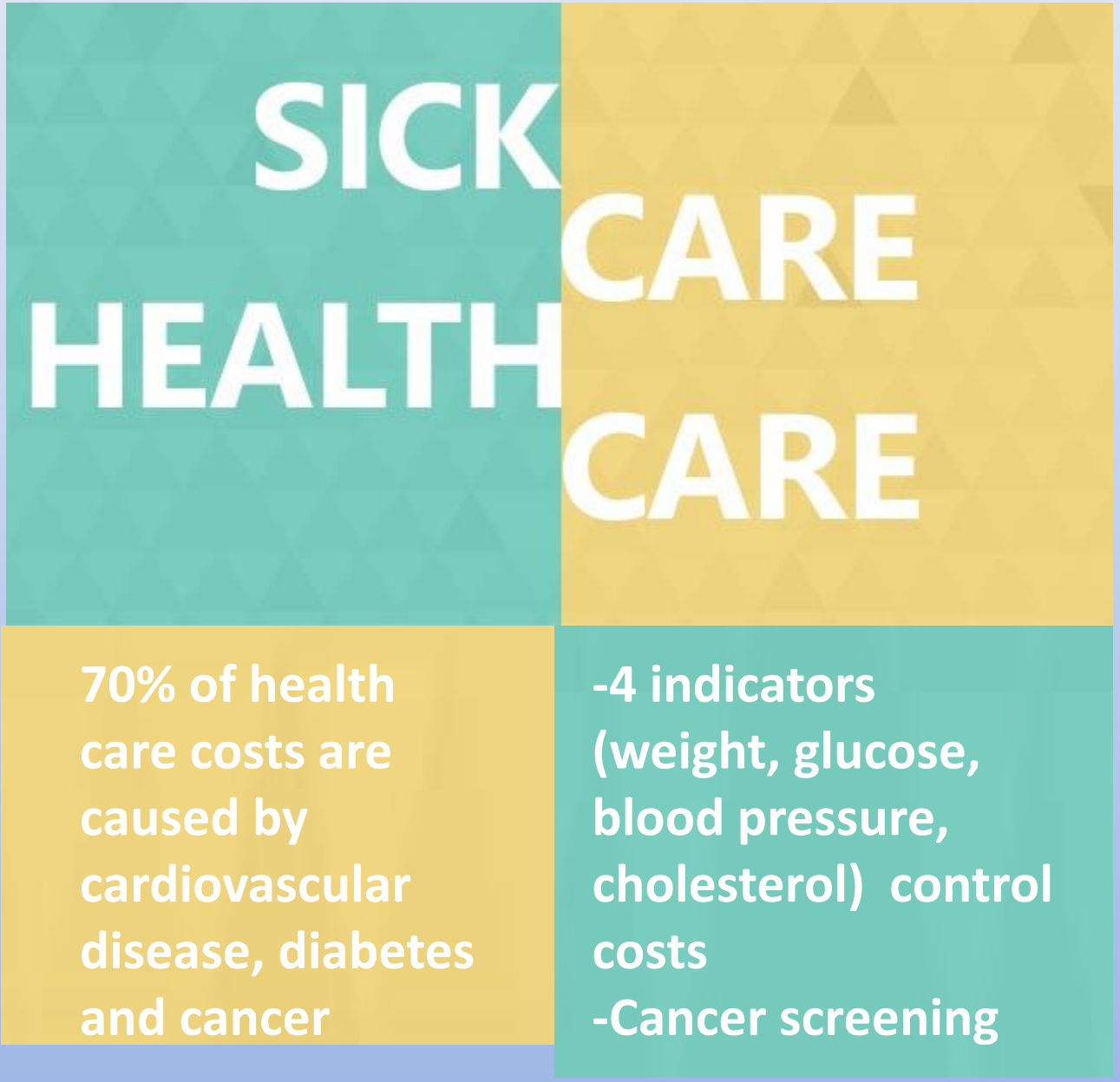



Gapminder.org

# Health Care spending




*US Billion USD

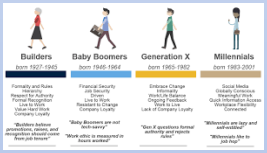



Marvasti NEJM 2012, Cigna 2015

# Health care > Sick care

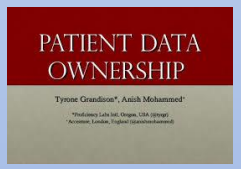
Personalized medicine


Tsunami of data




Diversity generations

AI




Data ownership consumer

Individual driven
Technology driven

Digital health

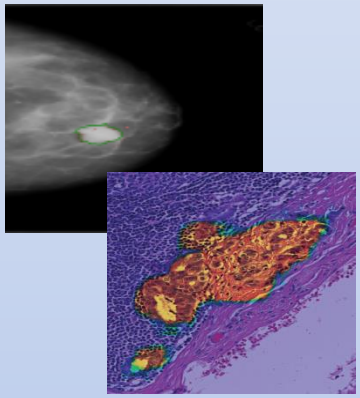
# Trends - Early detection

- Colorectal cancer 35% reduction in mortality 2400 of 7000 (37% reduction late stages)[1,2]
- Lung cancer ± 30 % reduction in mortality[3] (10%→50% stage 1 disease)
- Cervix cancer 70% reduction in mortality [4] (95% reduction in stage 3)

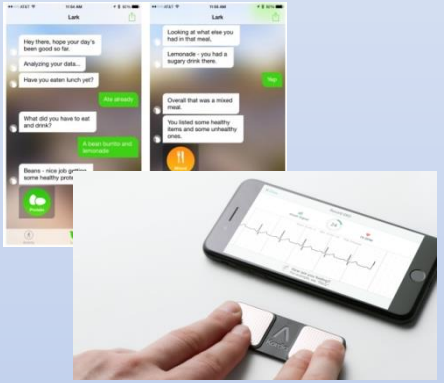
[1]Rapport Dutch Health Council
[2] Levin Gastroenterology 2018
[3]Resluts Nelson study 2018
[4]Landy Nature 2016

# Drivers

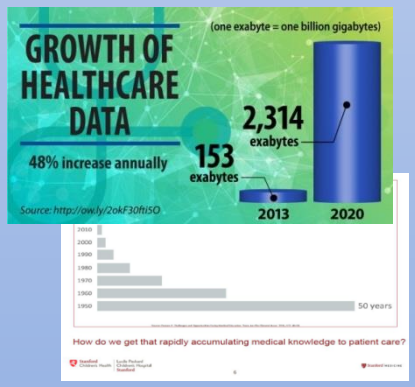
## AI



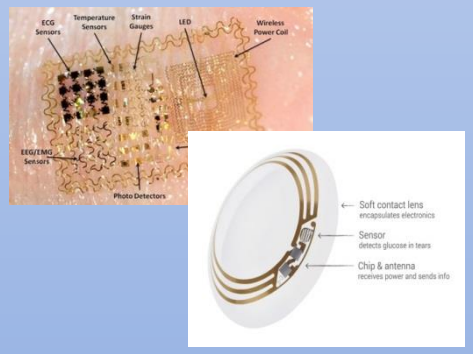
## Digital health




## Big data

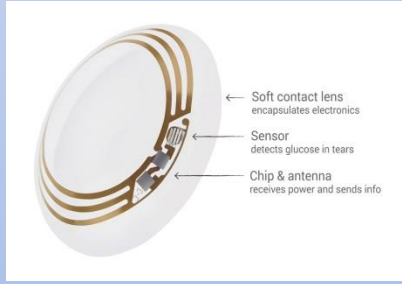



## Sensor technology

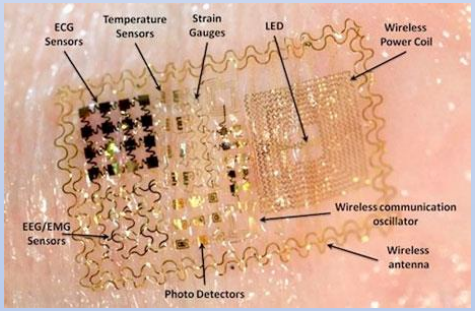


# Sensors: quantified self, home health


Watch

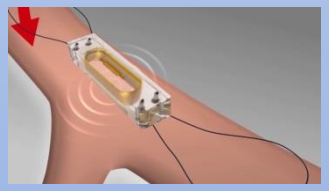


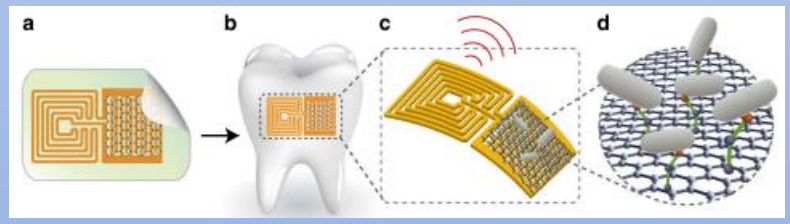

Lens




Skin

Blood stream

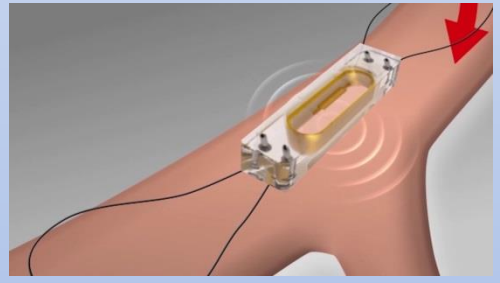





Teeth

# Connectivity: 24/7


**Lark app: Obesity, Diabetes, Hypertension**



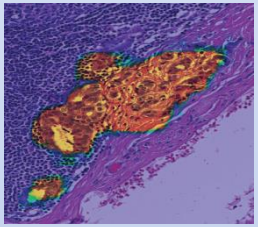
**CarioMEMS**

**Ping An Health 'internet hospital' Chatbot**

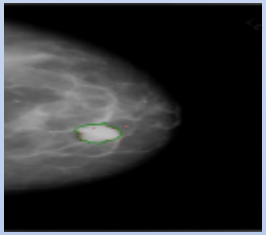
# Artificial Intelligence I

## Diagnostic field

**Pathology**
AI pathology analysis  lymph node metastasis breast



**Radiology**
AI to improve breast cancer screening mammography



**Dermatology**
AI for classifying melanoma skin lesion


JAMA®
The Journal of the American Medical Association

SCIENTIFIC REPORTS
natureresearch

nature
international weekly journal of science

## Digital consultant

A comparison of deep learning performance against health-care professionals in detecting diseases from medical imaging: a systematic review and meta-analysis

Xiaoxuan Liu*, Livia Faes*, Aditya U Kale, Siegfried K Wagner, Dun Jack Fu, Alice Bruynseels, Thushika Mahendiran, Gabriella Moraes, Mohith Shamdas, Christoph Kern, Joseph R Ledsam, Martin K Schmid, Konstantinos Balaskas, Eric J Topol, Lucas M Bachmann, Pearse A Keane, Alastair K Denniston

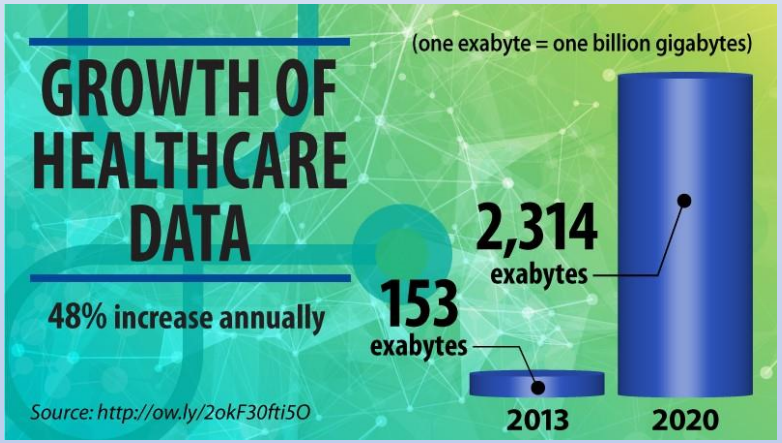
Bejnordi JAMA 2017, Li Shen Nature 2019, Esteva, Nature 2017
Li lancer digital health 2019

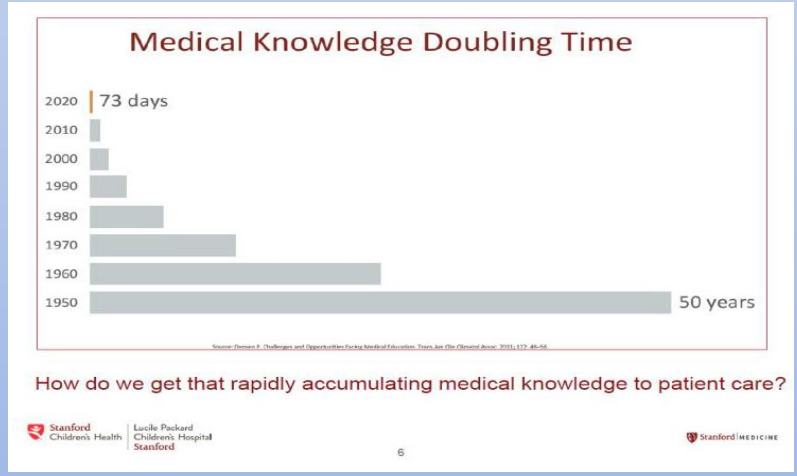
# Big data analytics

Treatment field

- Personalized medicine
- Treatment algorithms
- Replace MDT

Patient guidance

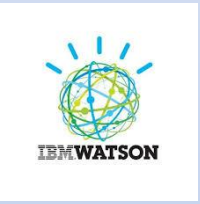


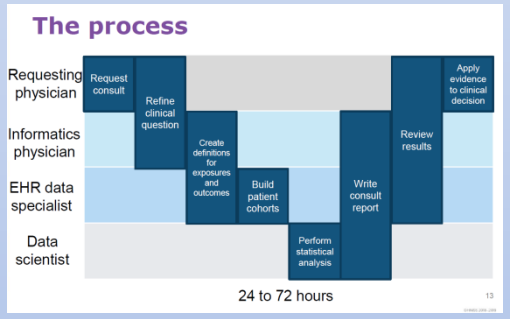
# Other players

## Treatment field

- IBM Watson failed




- The Green button project (Harvard)[1]




- Apple Health, Anthem, China[2]


## Patient guidance

[1]Callahan HIMS 2019, Guiyang,

# Location / suppliers

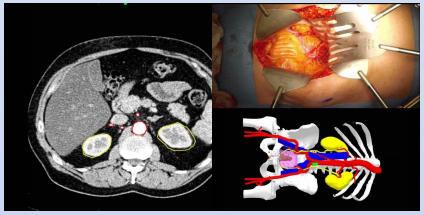
Care moves outside hospitals

Other suppliers enter the market

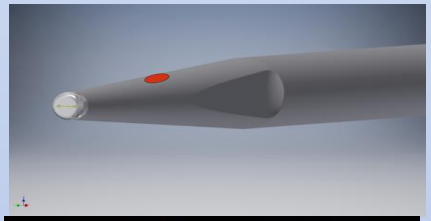
Hospital care technology driven

# Surgical Oncology: Technologies at the verge

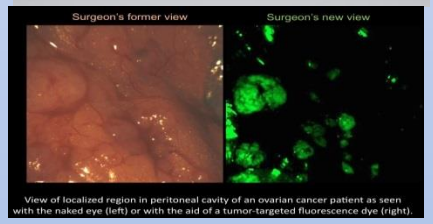
Surgical navigation



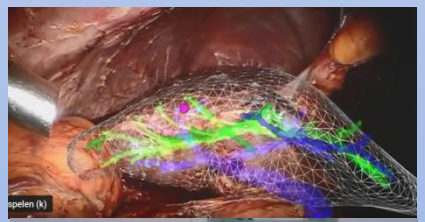
Tissue sensing



Molecular fluorescence-guided surgery

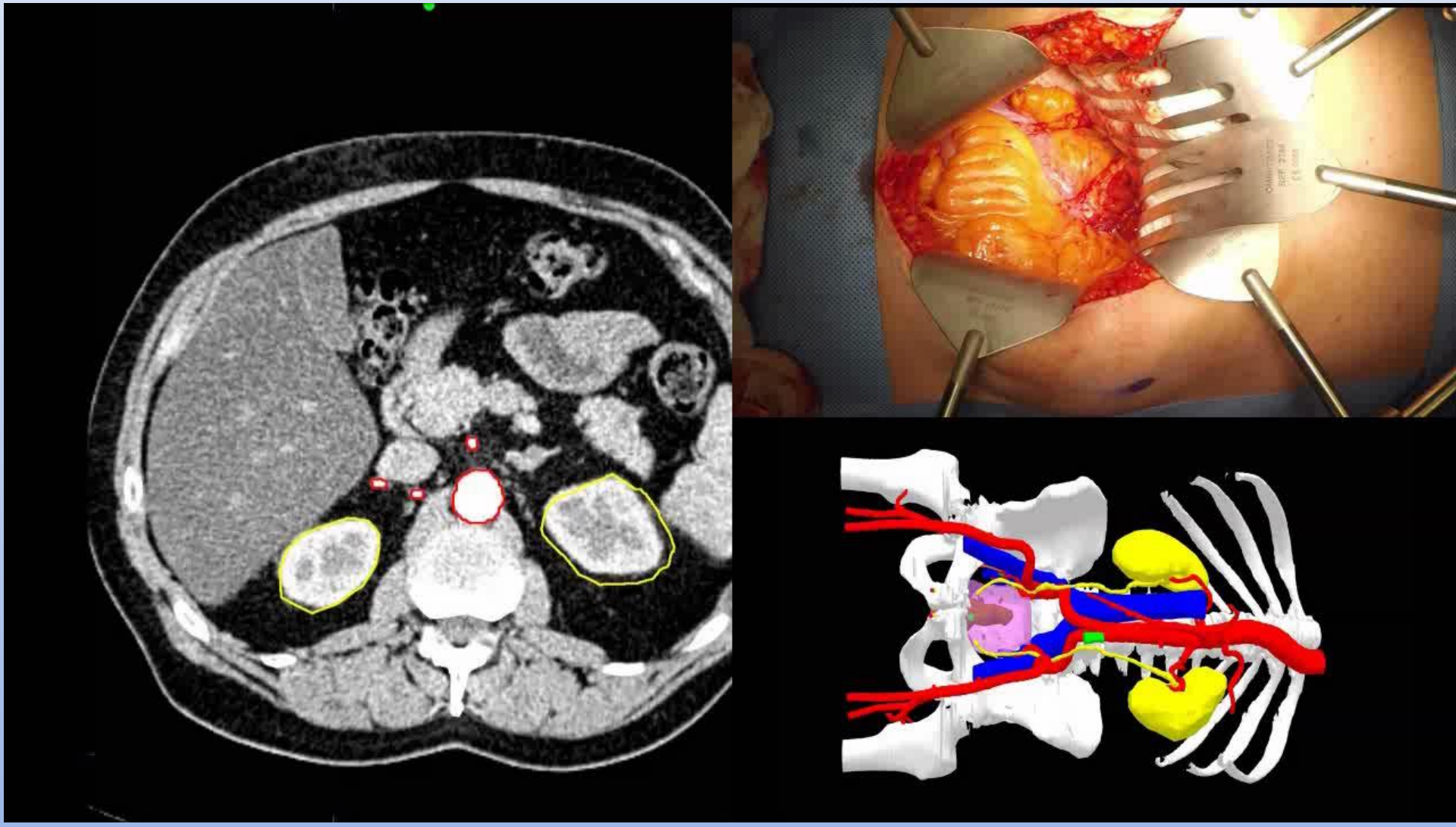



Computerized assisted surgery

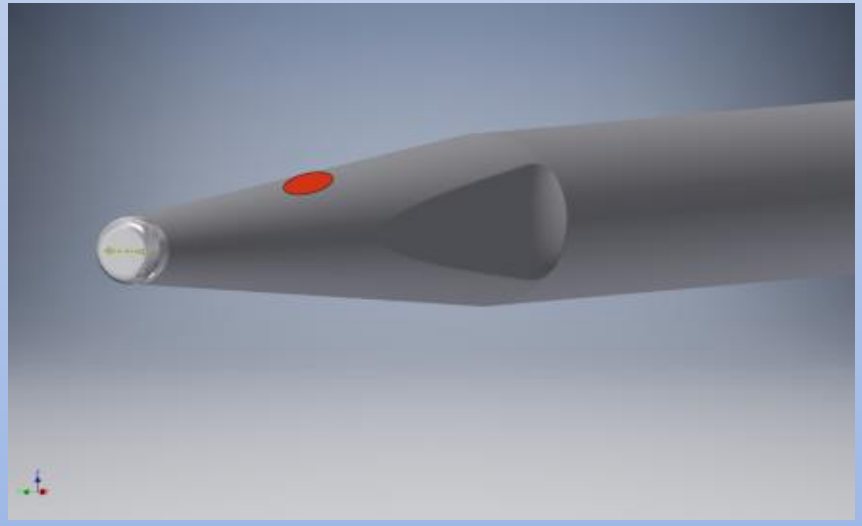


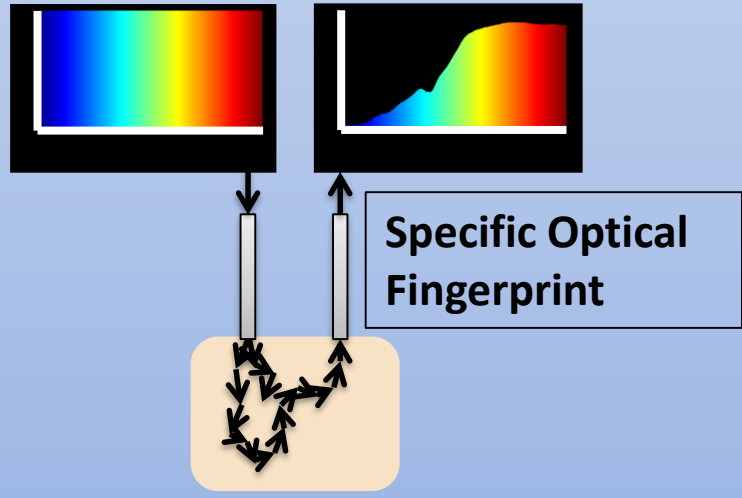
Robotics

# Surgical navigation

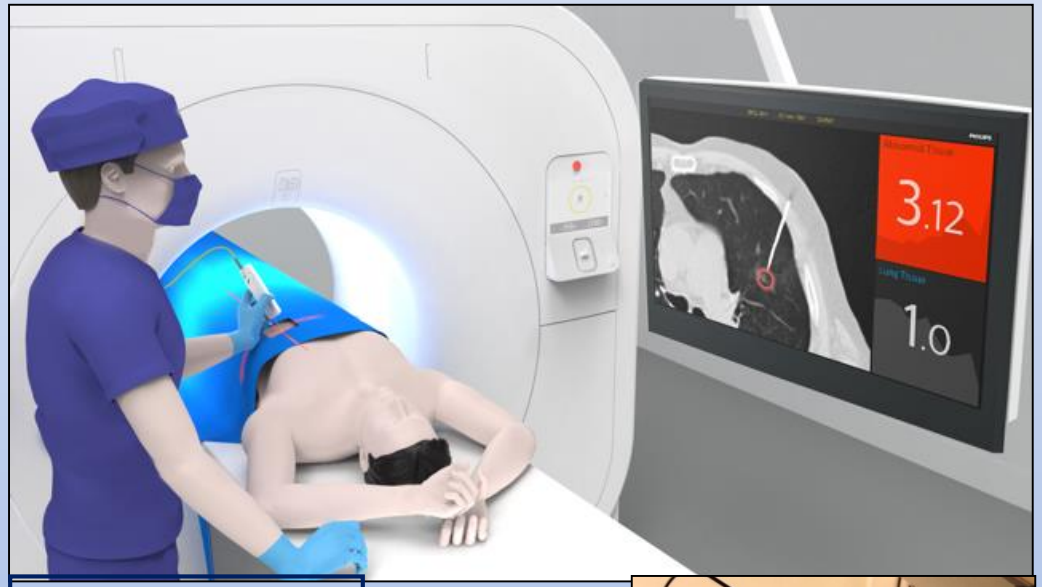


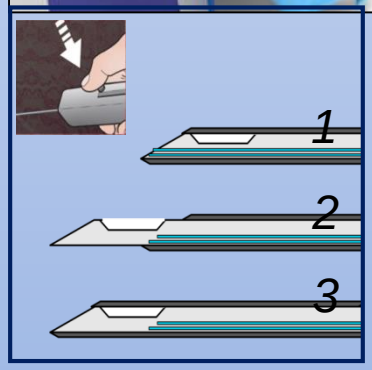
# Smart optical tools

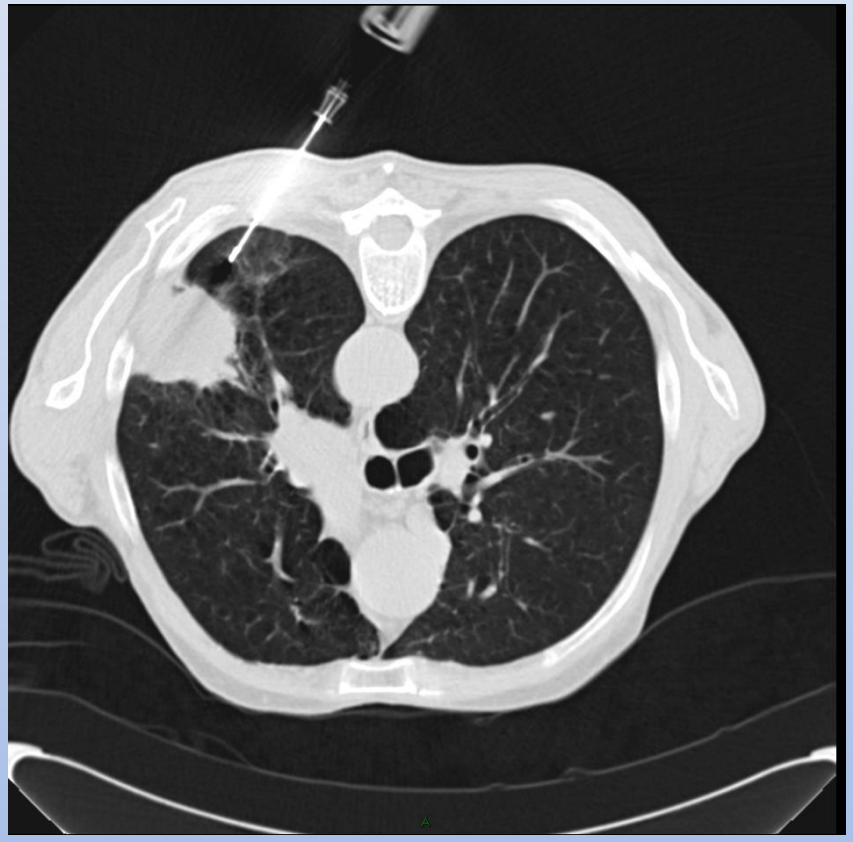



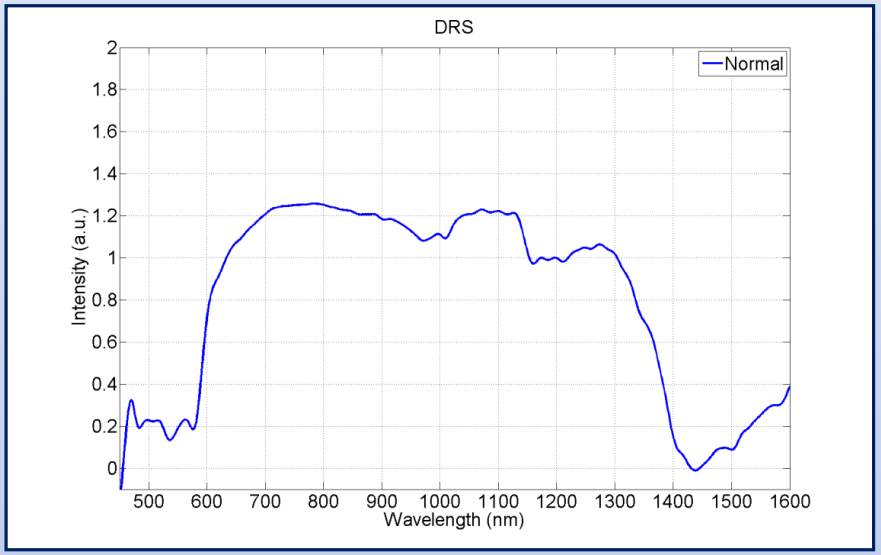


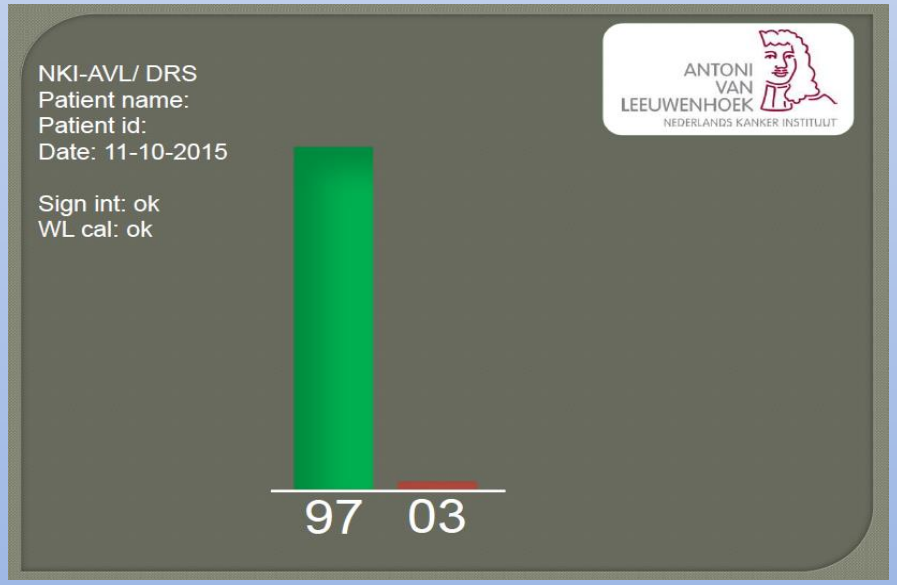
# Clinical translation for lung cancer




DRS
Normal
Intensity (a.u.)
Wavelength (nm)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600


NKI-AVL/ DRS
Patient name:
Patient id:
Date: 11-10-2015
Sign int: ok
WL cal: ok
ANTONI VAN LEEUWENHOEK
NEDERLANDS KANKER INSTITUUT
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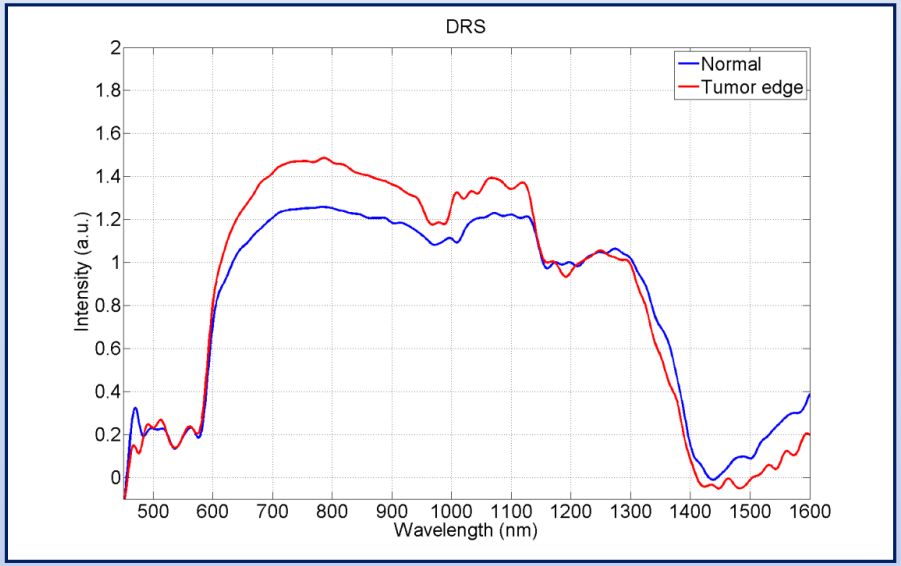
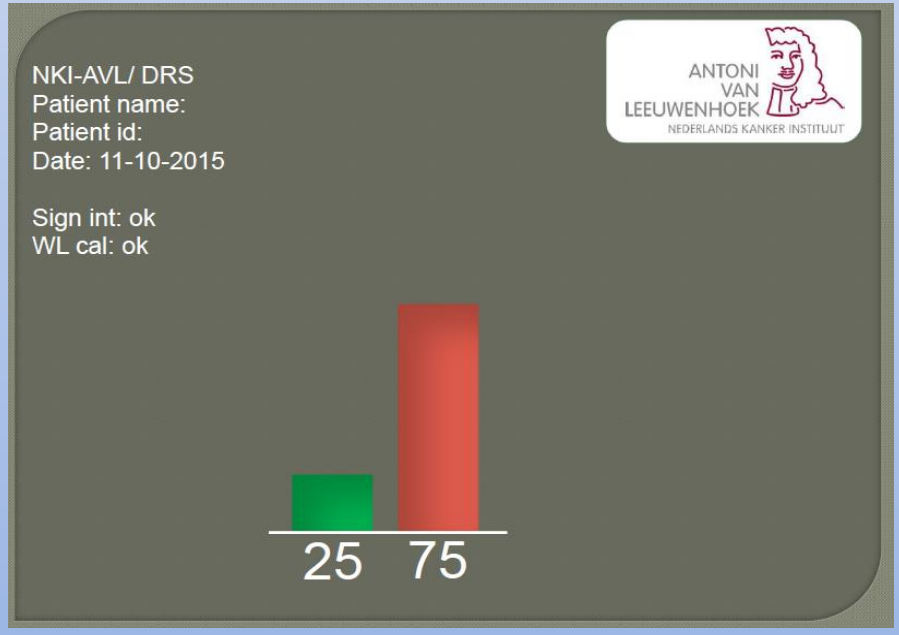
03


DRS
Normal
Tumor edge
Intensity (a.u.)
Wavelength (nm)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600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NEDERLANDS KANKER INSTITUUT
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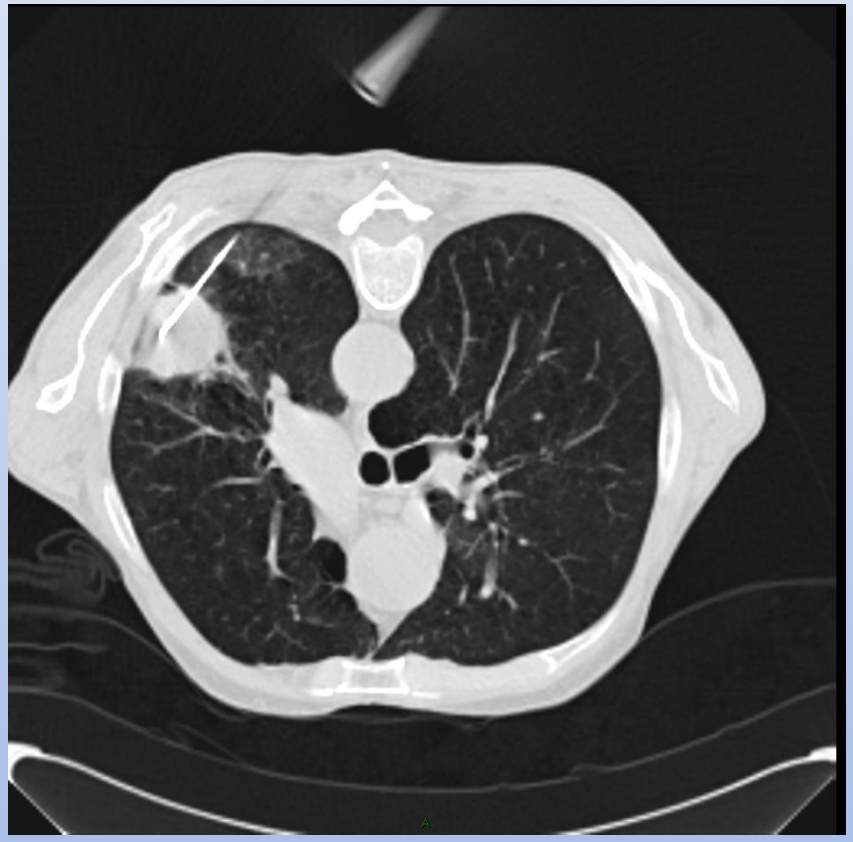

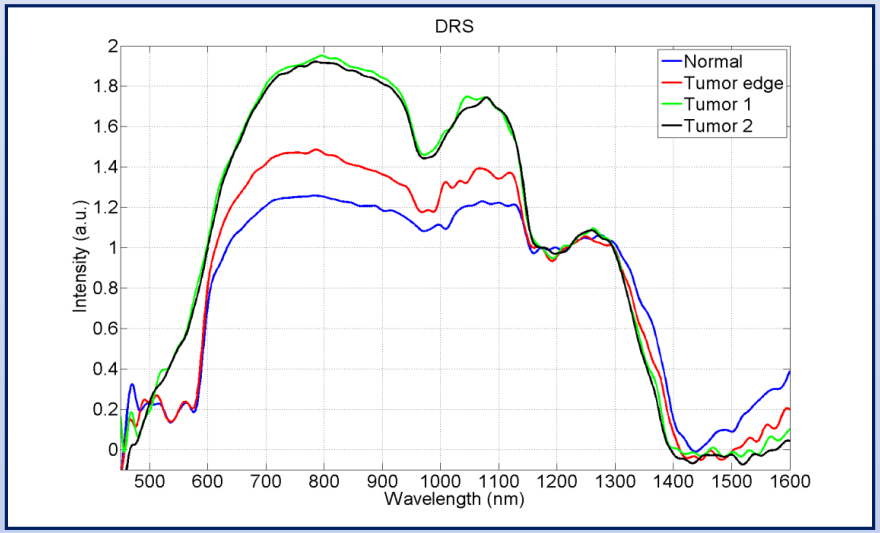
DRS
Normal
Tumor edge
Tumor 1
Tumor 2
Intensity (a.u.)
Wavelength (nm)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
500
600
700
800
900
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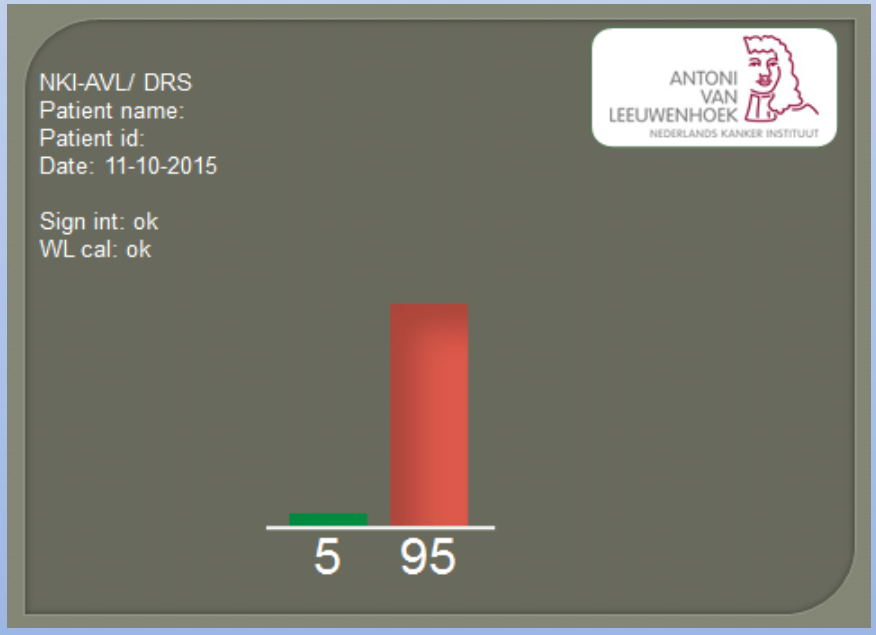
1500
1600


NKI-AVL/ DRS
Patient name:
Patient id:
Date: 11-10-2015
Sign int: ok
WL cal: ok
ANTONI VAN LEEUWENHOEK
NEDERLANDS KANKER INSTITUUT
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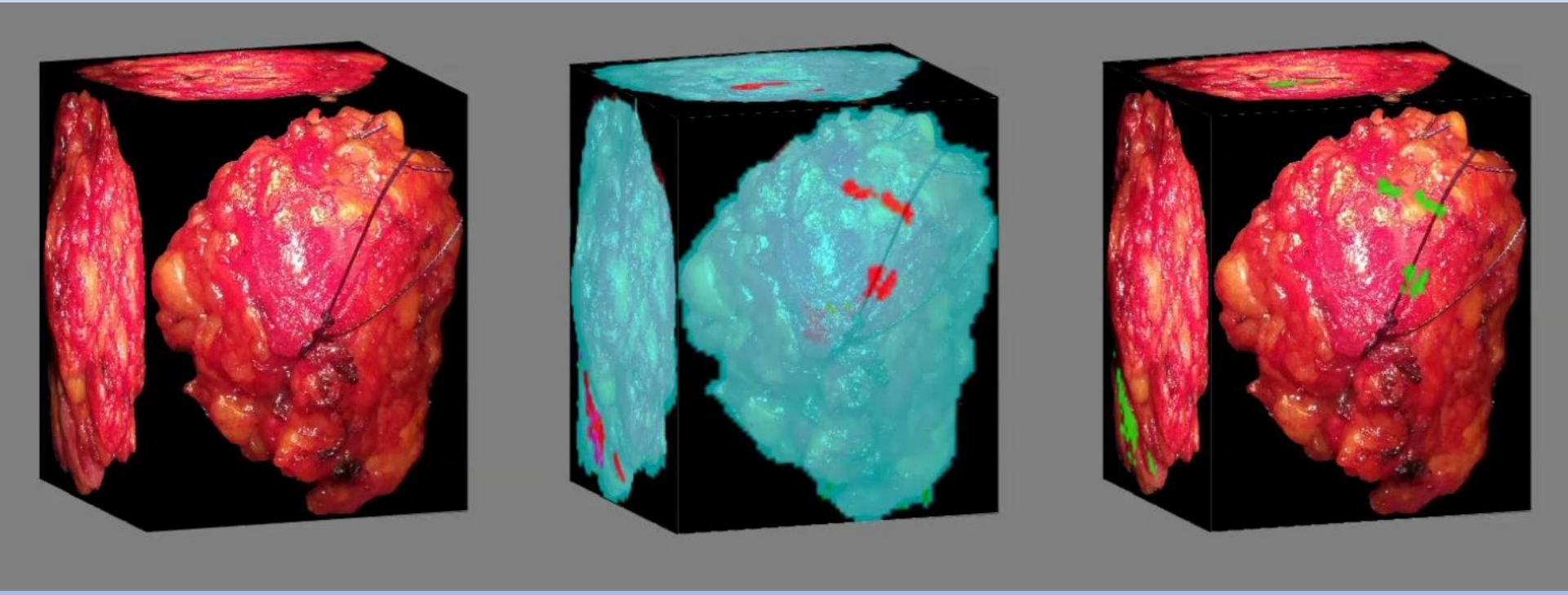
95

# Hyperspectral Imaging

**Normal camera**

**Hyperspectral camera**

**Fused image**




# The Netherlands Cancer Institute

The Netherlands Cancer Institute is one of top 10 comprehensive cancer centers in Europe. Because treatment and research are placed under one roof, promising technologies can quickly find their way to the clinic; from bench to bedside.

To optimize this process, we have a large research infrastructure including a Clinical Data Center and Trial Registration Office that can advise and assist with complying to national guidelines, medical ethical approval and data collection. In addition, our clinical implementation team with dedicated technical people implements medical technology into daily clinical practice.

This makes us well equipped to participate in national as well as international projects, such as Horizon 2020.

**Contact: t.ruers@nki.nl**

NETHERLANDS CANCER INSTITUTE
ANTONI VAN LEEUWENHOEK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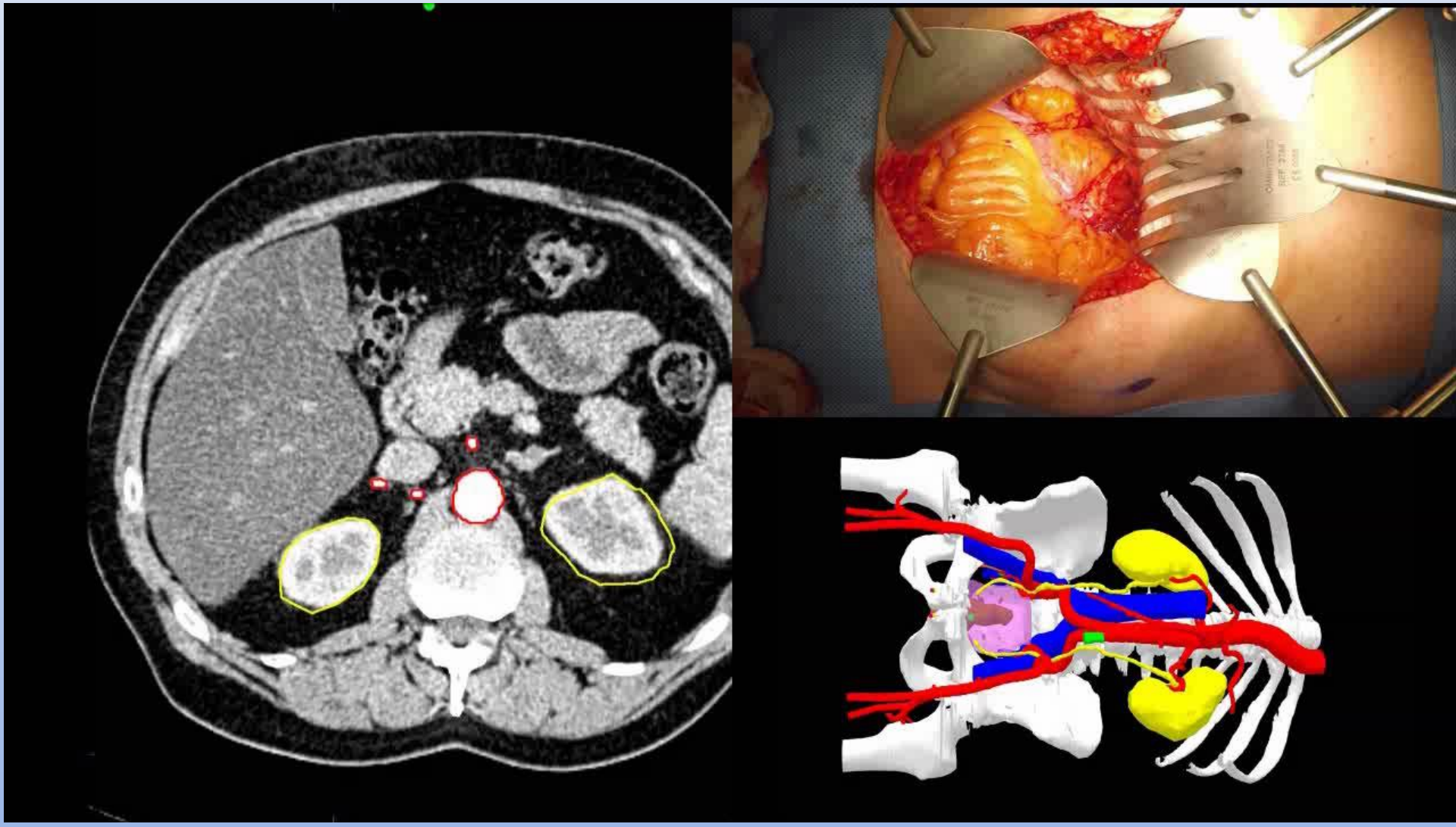
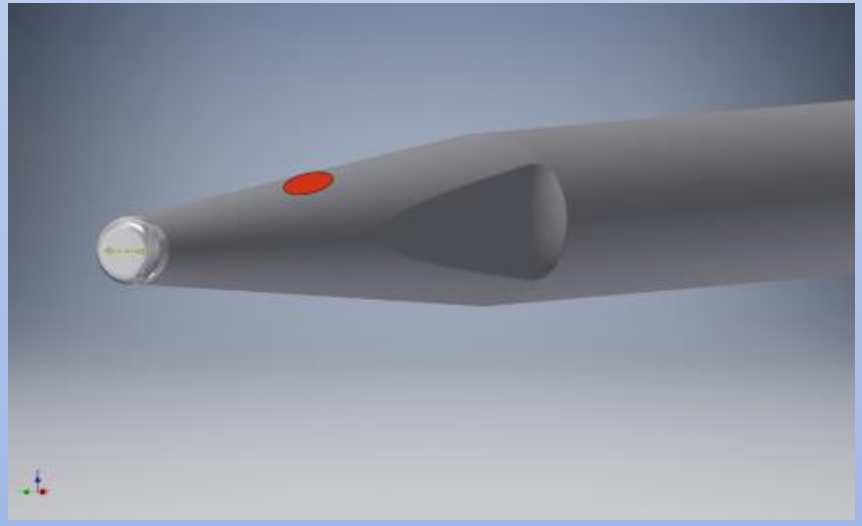
NETHERLANDS CANCER INSTITUTE
ANTONI VAN LEEUWENHOEK

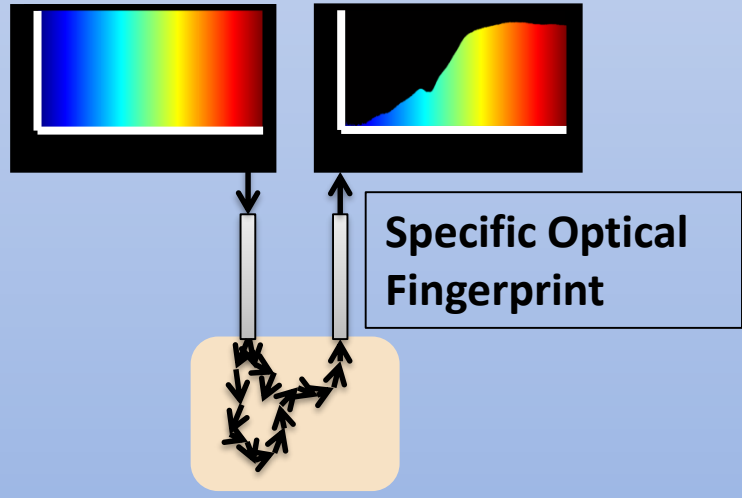
# The Future of Surgical Oncology

# Surgical navigation

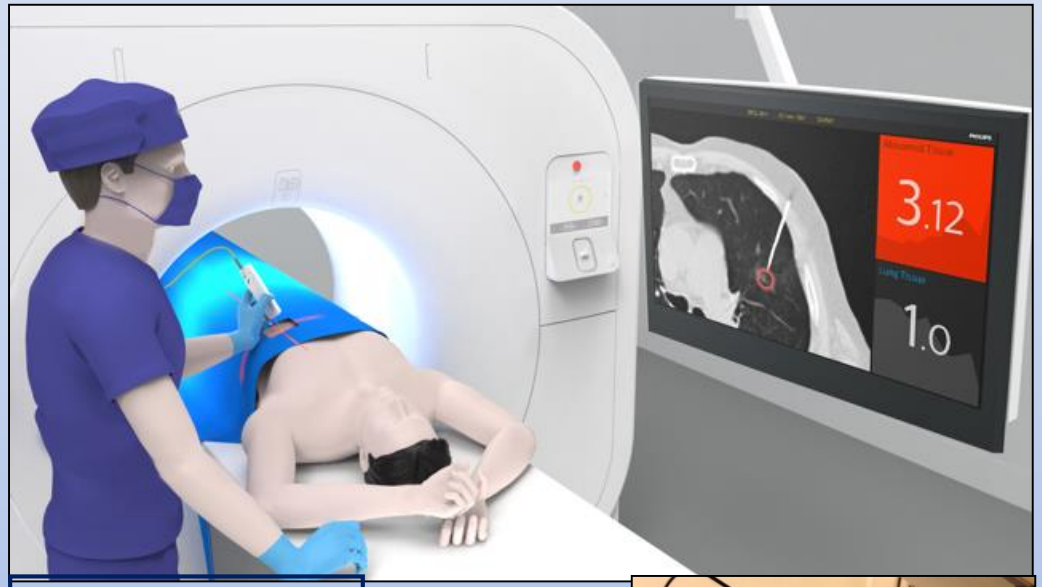


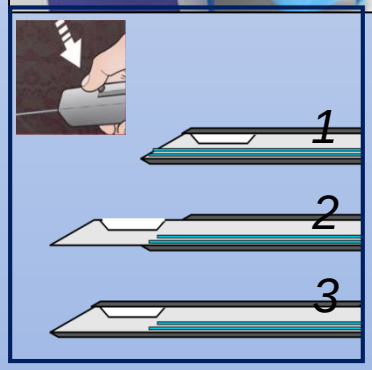
# Smart optical tools

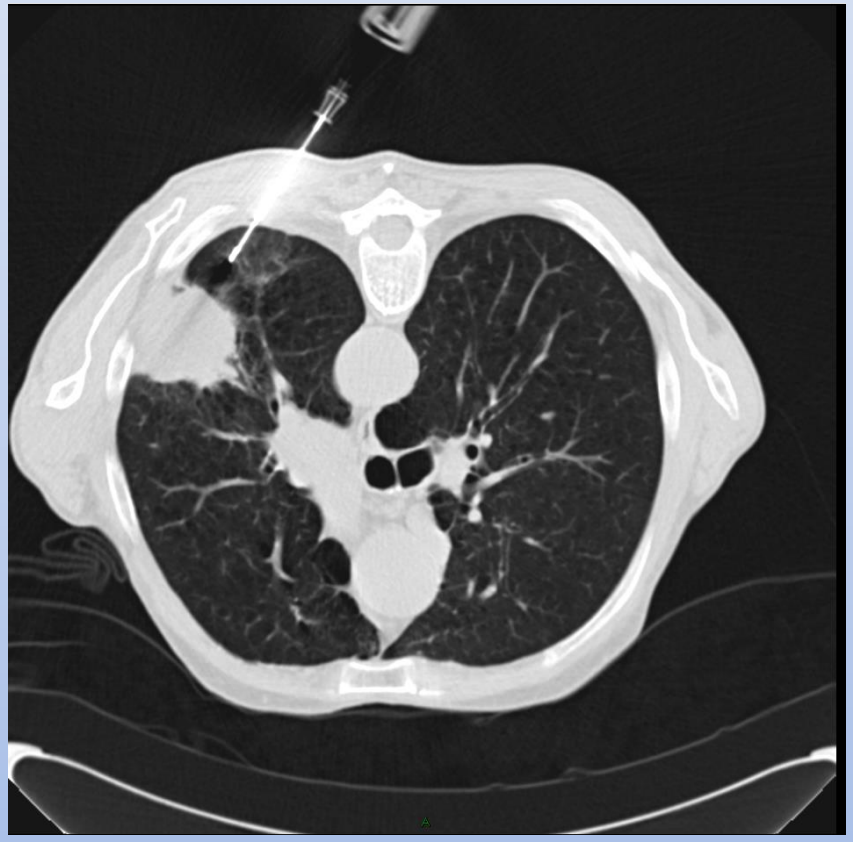



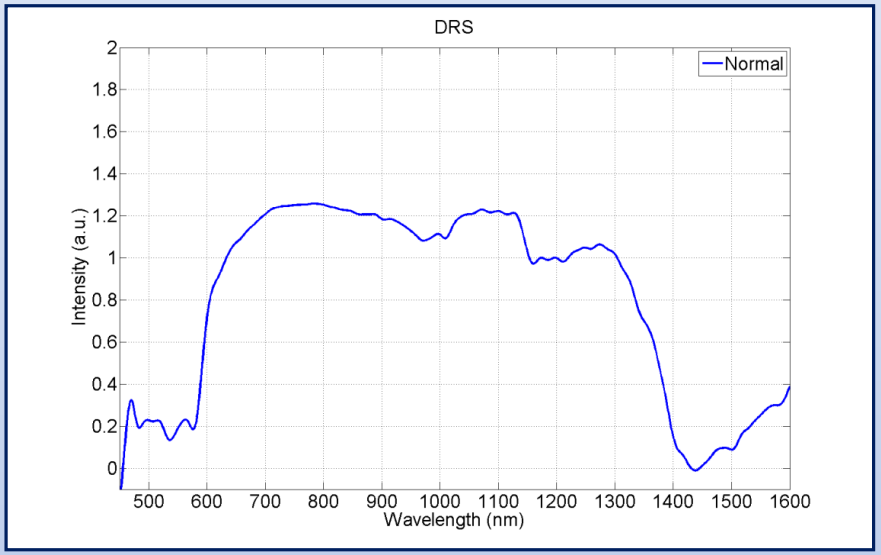


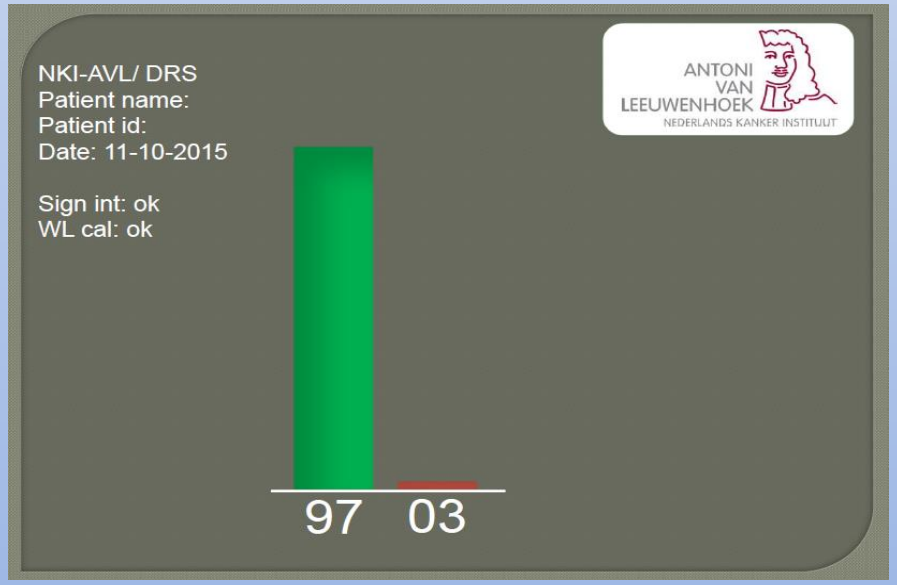
# Clinical translation for lung cancer

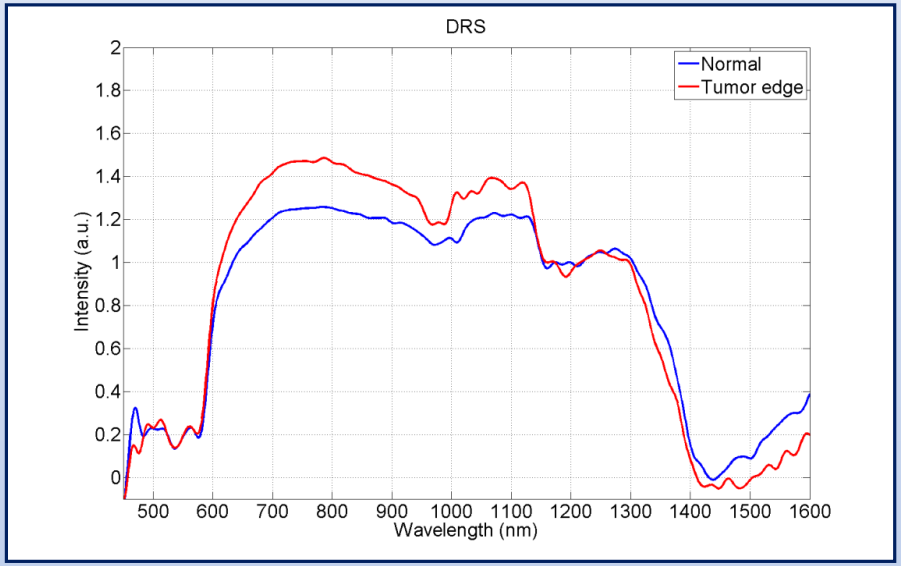


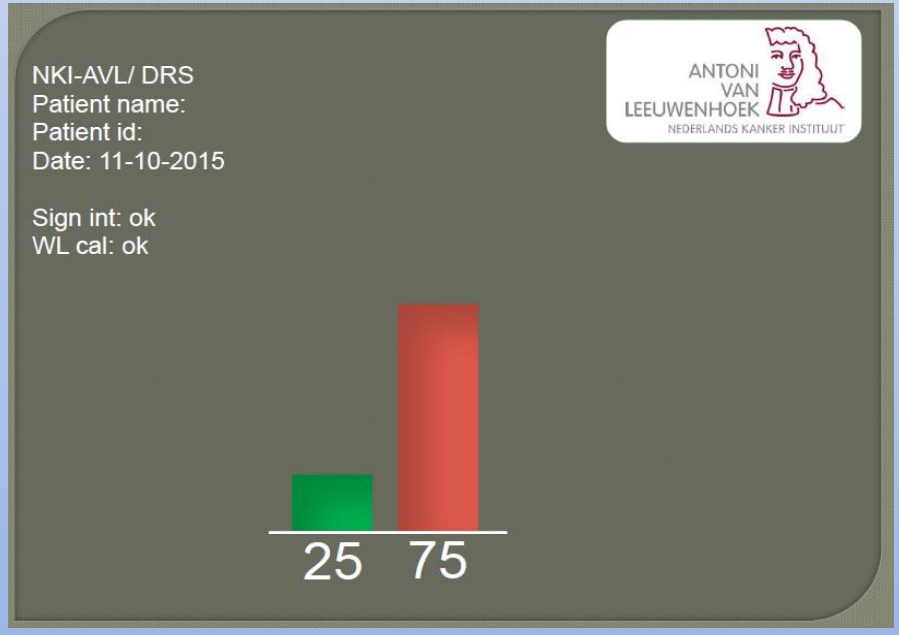



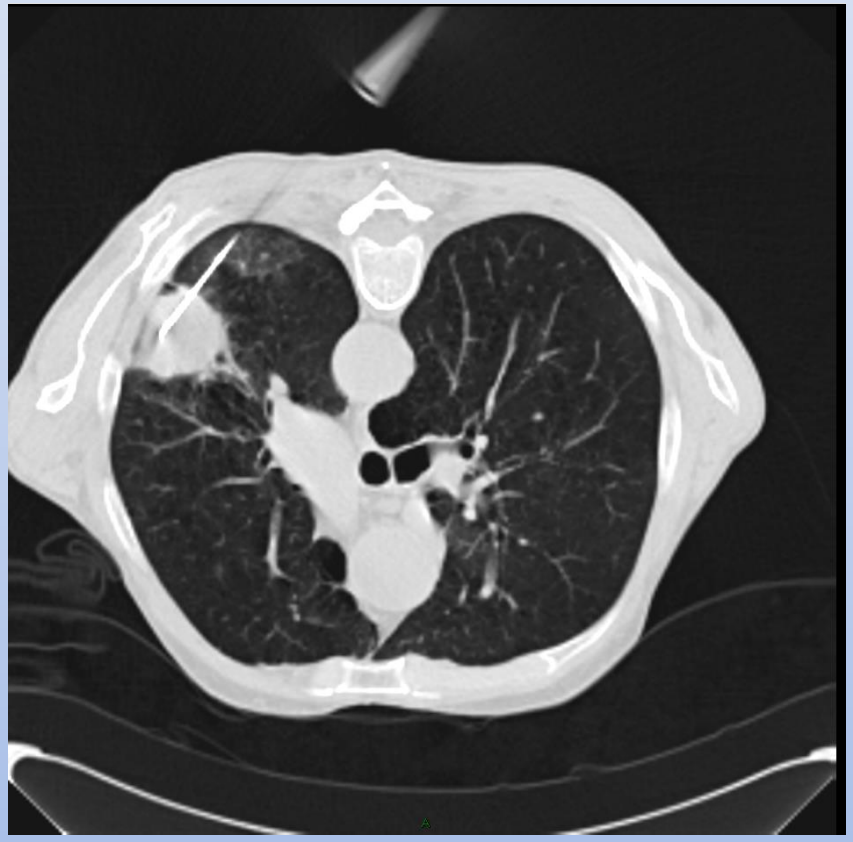



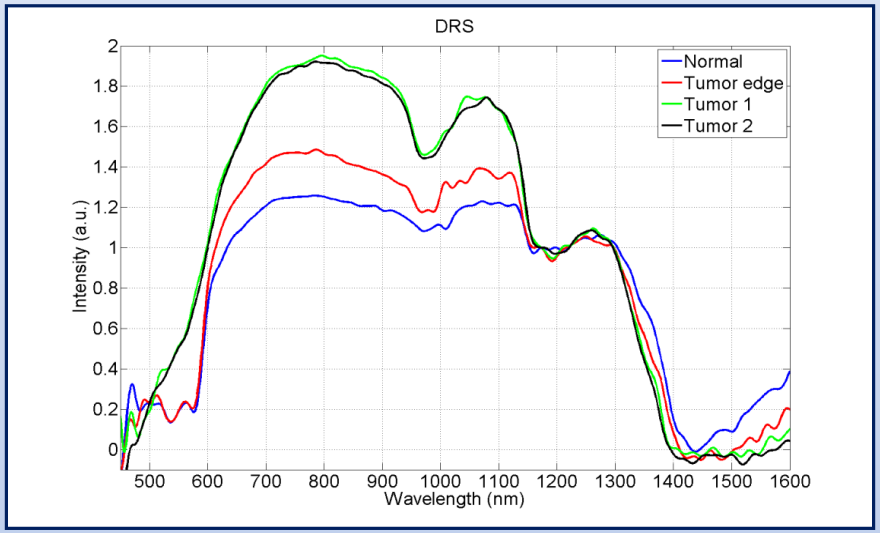

DRS
Normal
Intensity (a.u.)
Wavelength (nm)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600

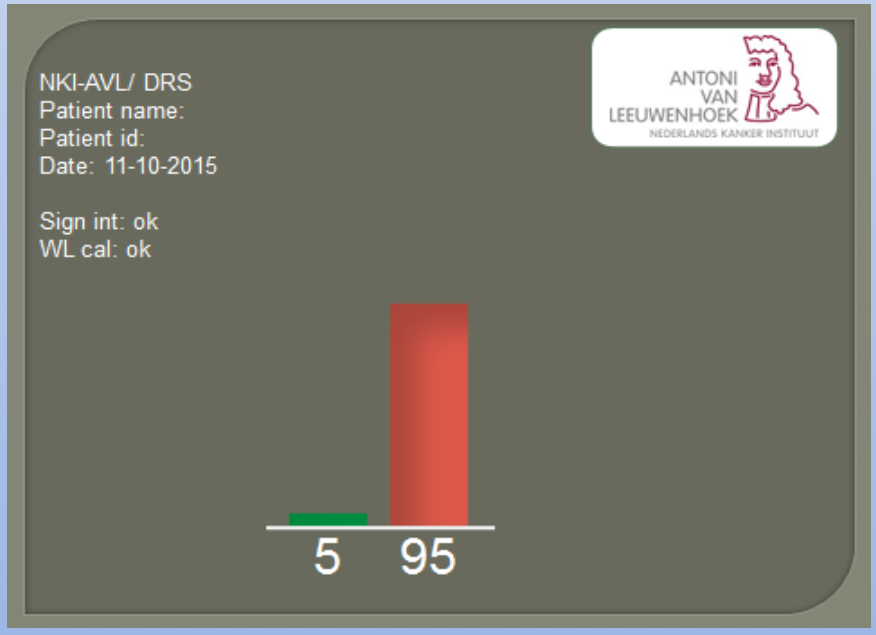

NKI-AVL/ DRS
Patient name:
Patient id:
Date: 11-10-2015
Sign int: ok
WL cal: ok
ANTONI VAN LEEUWENHOEK
NEDERLANDS KANKER INSTITUUT
97
03


DRS
Normal
Tumor edge
Intensity (a.u.)
Wavelength (nm)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600


NKI-AVL/ DRS
Patient name:
Patient id:
Date: 11-10-2015
Sign int: ok
WL cal: ok
ANTONI VAN LEEUWENHOEK
NEDERLANDS KANKER INSTITUUT
25
75




DRS
Normal
Tumor edge
Tumor 1
Tumor 2
Intensity (a.u.)
Wavelength (nm)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600

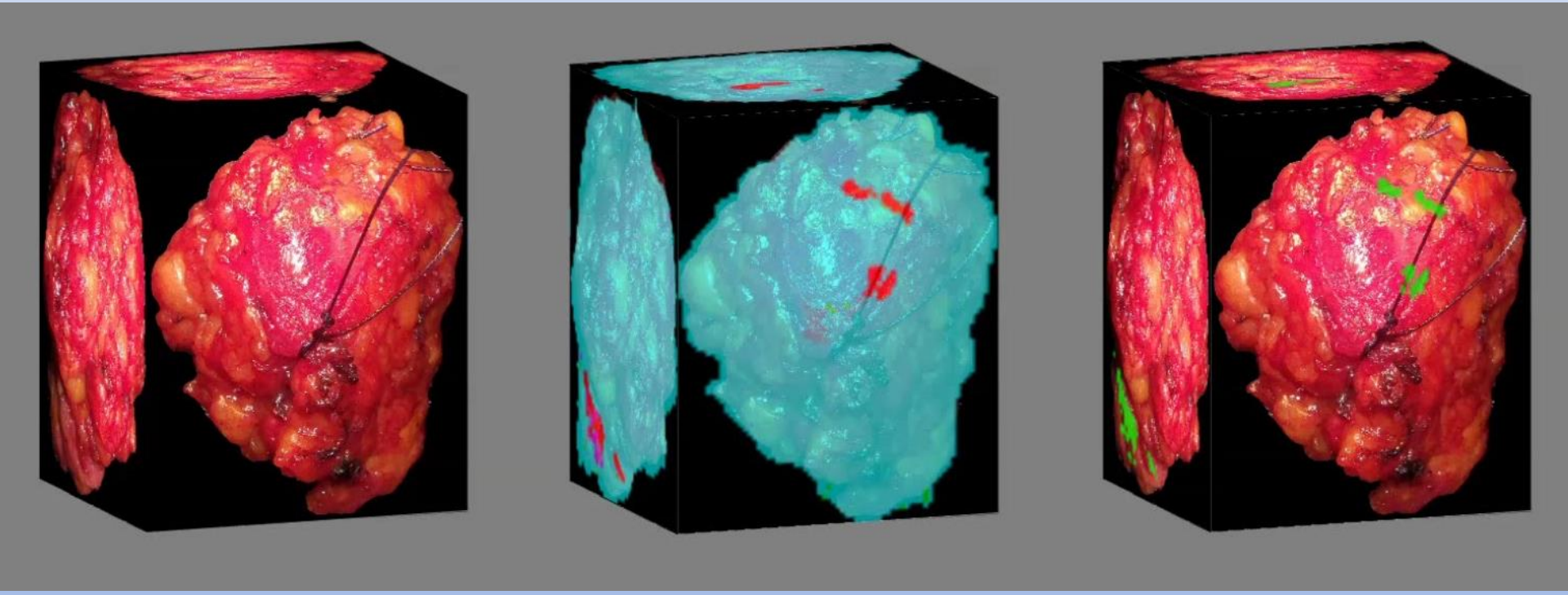

NKI-AVL/ DRS
Patient name:
Patient id:
Date: 11-10-2015
Sign int: ok
WL cal: ok
ANTONI VAN LEEUWENHOEK
NEDERLANDS KANKER INSTITUUT
5
95

# Imaging result

**Normal camera**

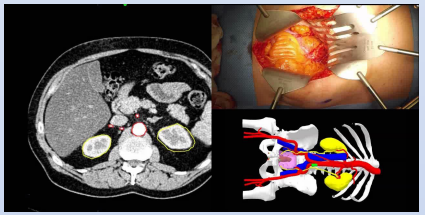
**Hyperspectral camera**

**Fused image**

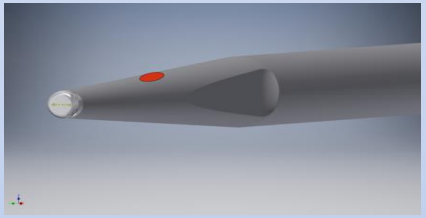


# Technologies at the verge

Surgical navigation

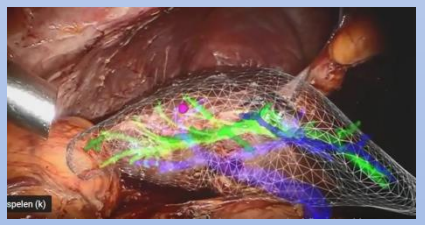


Tissue sensing



Molecular fluorescence-guided surgery


Computerized assisted surgery



Robotics

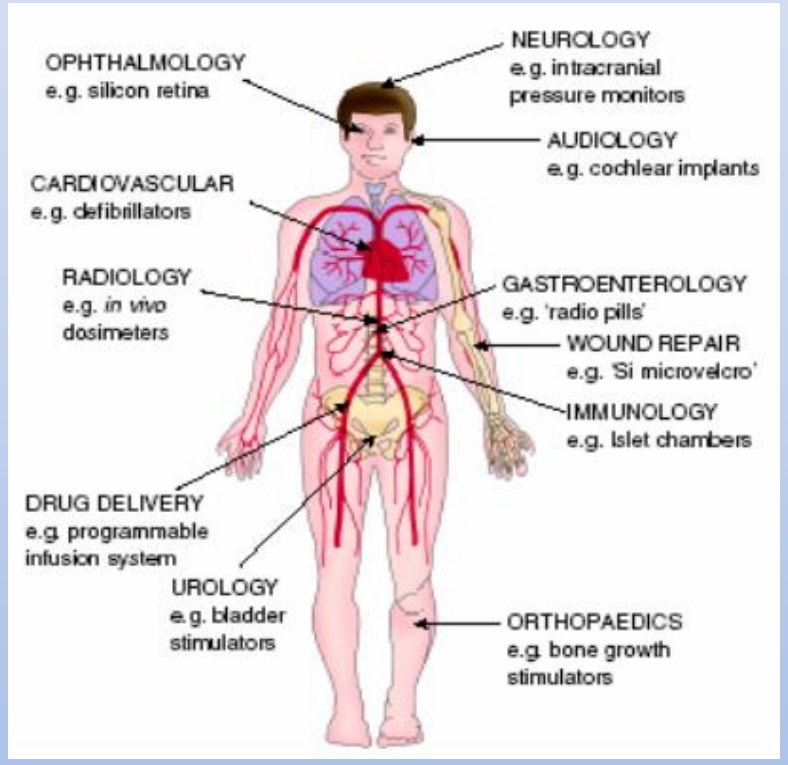
## Physical - Applications

**Wearable Physical Sensor:**

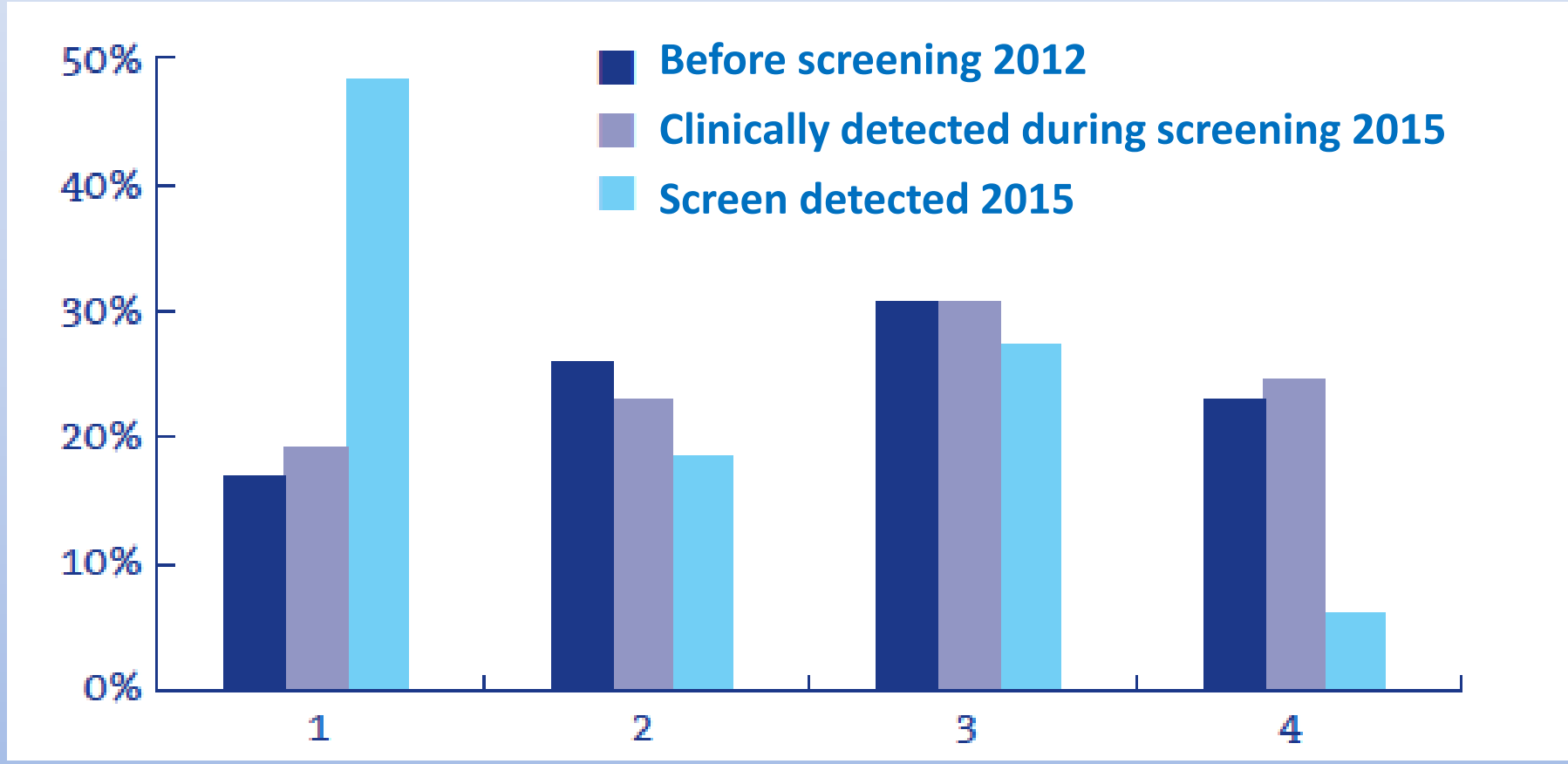
- Heart Rate
- Blood Pressure/Oxygen Level
- Body Temperature
- Thermotherapy
- Muscle Contractions
- Gait (Glaucoma)
- Extravasation
- Respiration

**Implantable Physical Sensor:**

- Intraocular Pressure
- Intracranial Pressure
- Bladder Pressure and Contraction Onset
- LV Pressure
- Arterial Strain (Atherosclerosis)
- Blood Pressure (e.g. Stent monitoring)
- Radiation Dose
- Tumor Interstitial Pressure
- Cardiovascular Diagnostics
- Bone Growth



# Stage distribution



# World Map: Sensor Groups


Universities, companies, research institutes working on wearable or implantable sensors

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# EPIC Meeting on Photonics for Cancer Diagnostics and Treatment 2019

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