

AACR VIRTUAL SPECIAL CONFERENCE

# ARTIFICIAL INTELLIGENCE, DIAGNOSIS, AND IMAGING

January 13-14, 2021

**AACR**

American Association  
for Cancer Research®

FINDING CURES TOGETHER®

# Deep Learning Radiomics in Cancer Imaging

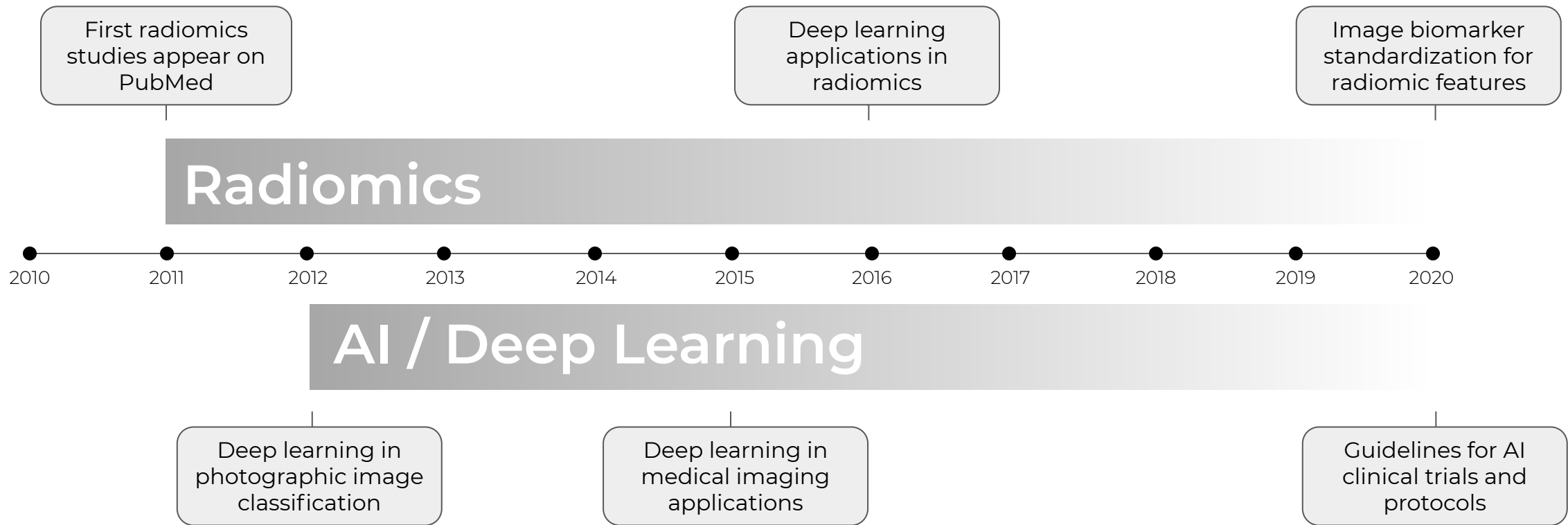
*Ahmed Hosny*

Plenary Session 2: Learning from Images: Radiomics  
AACR Special Conference on Artificial Intelligence, Diagnosis, and Imaging  
January 13, 2021

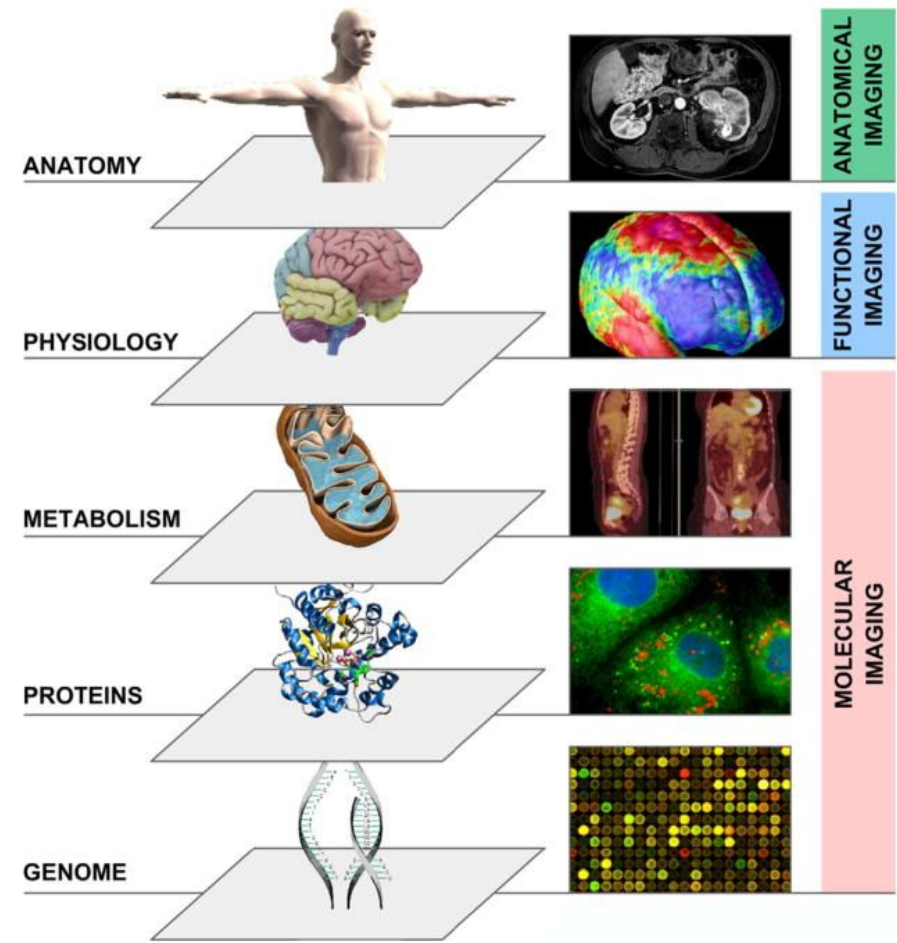
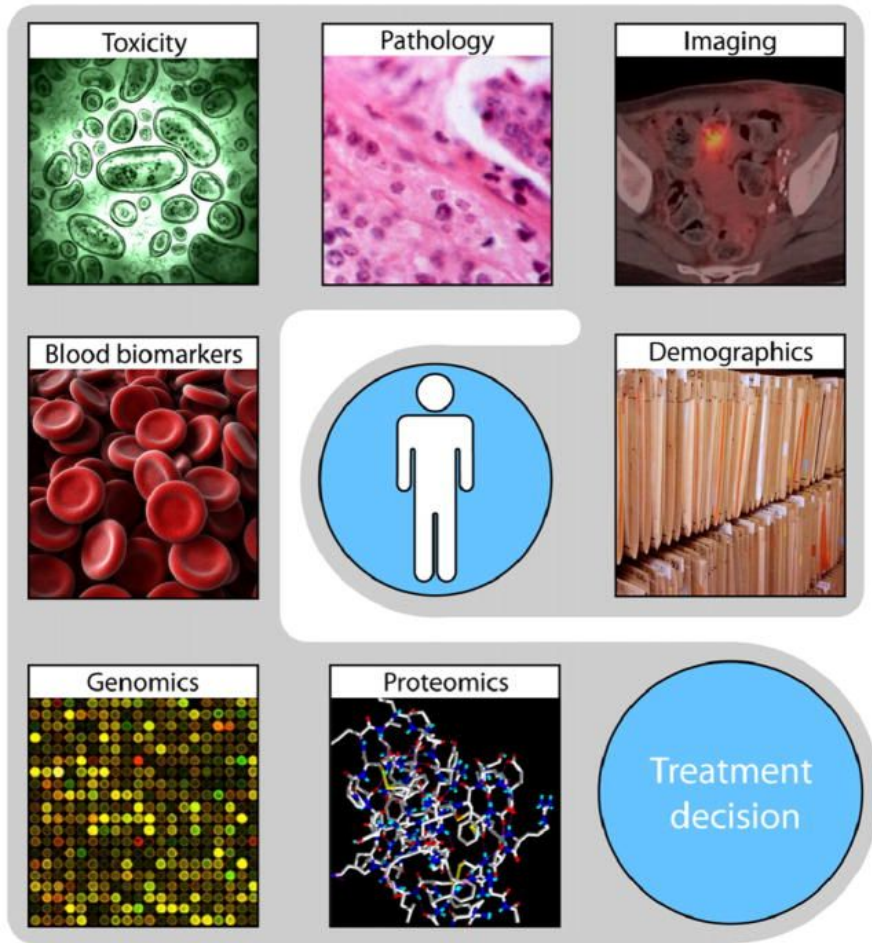


Disclosure Information: Scientific advisor and shareholder of Altis Labs Inc. I will not discuss off label use and/or investigational use in my presentation.

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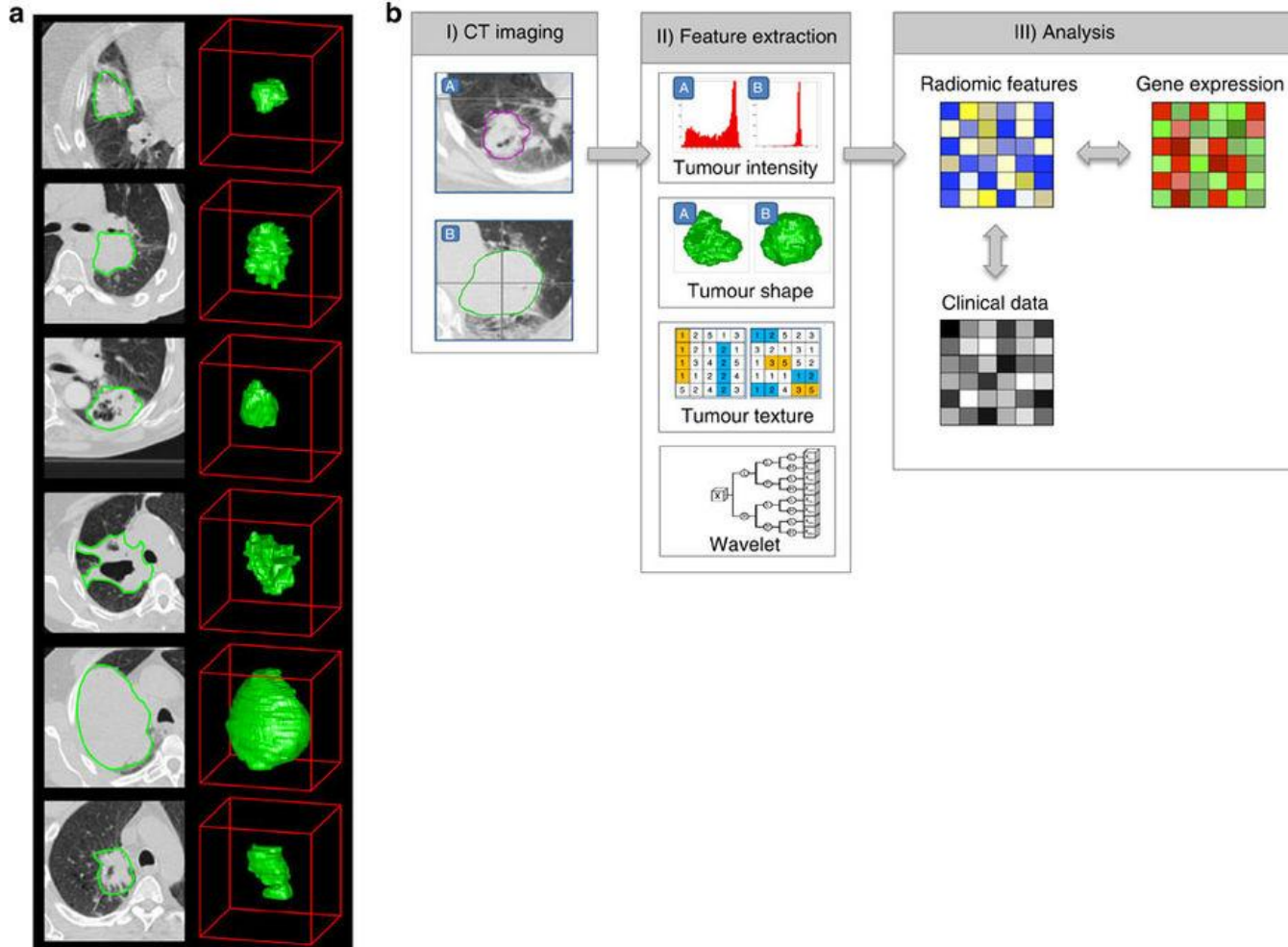




P Lambin, ER Velazquez, R Leijenaar, S Carvalho, RGPM Stiphout, P Granton, CML Zegers, R Gillies, R Boellard, A Dekker, HJWL Aerts

# Radiomics: Extracting more Information from Medical Images using Advanced Feature Analysis

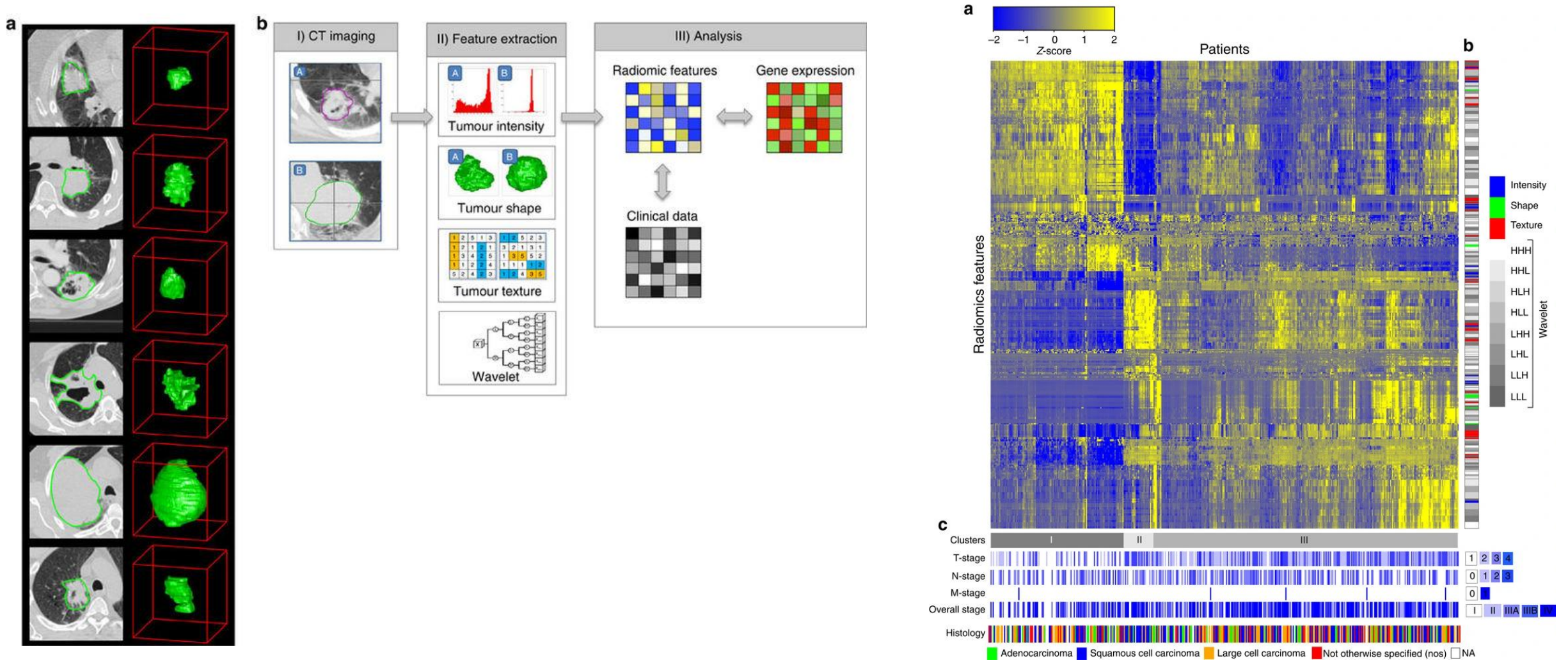
European Journal of Cancer 2012



HJWL Aerts, E Velazquez, RTH Leijenaar, C Parmar, P Grossmann, S Carvalho, J Bussink, R Monshouwer, B Haiibe-Kains, D Rietveld, F Hoebbers, et al.

# Decoding Tumour Phenotype by Non-invasive Imaging using a Quantitative Radiomics Approach

Nature Communications 2014



HJWL Aerts, E Velazquez, RTH Leijenaar, C Parmar, P Grossmann, S Carvalho, J Bussink, R Monshouwer, B Haibe-Kains, D Rietveld, F Hoebbers, et al.

# Decoding Tumour Phenotype by Non-invasive Imaging using a Quantitative Radiomics Approach

Nature Communications 2014



AIM-Harvard / pyradiomics

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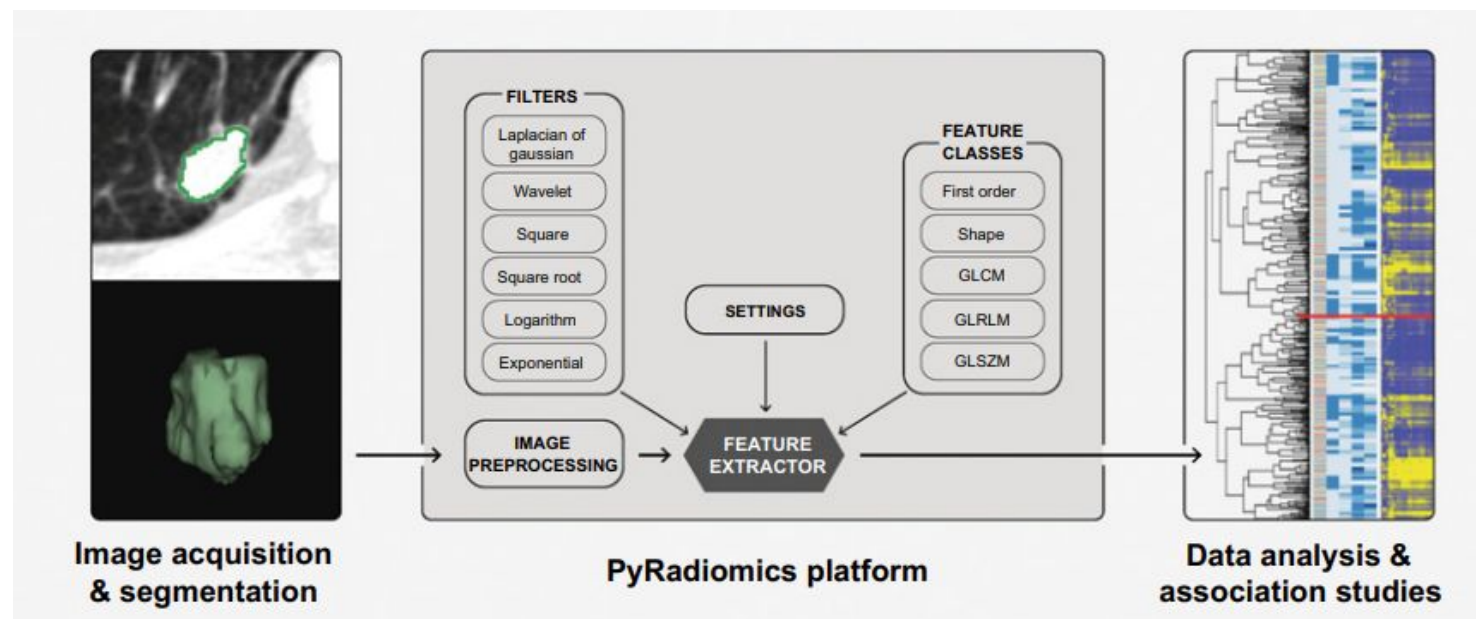
fedorov update the community link ec53d1d 13 days ago 1,167 commits

.circleci	TESTING: Remove testing for Python 2.7	11 months ago
.github/ISSUE_TEMPLATE	Update Issue templates	11 months ago
bin	ENH: Update Matrices test script	3 years ago

About

Open-source python package for the extraction of Radiomics features from 2D and 3D images and binary masks. Support: <https://discourse.slicer.org/c/community/radiomics>

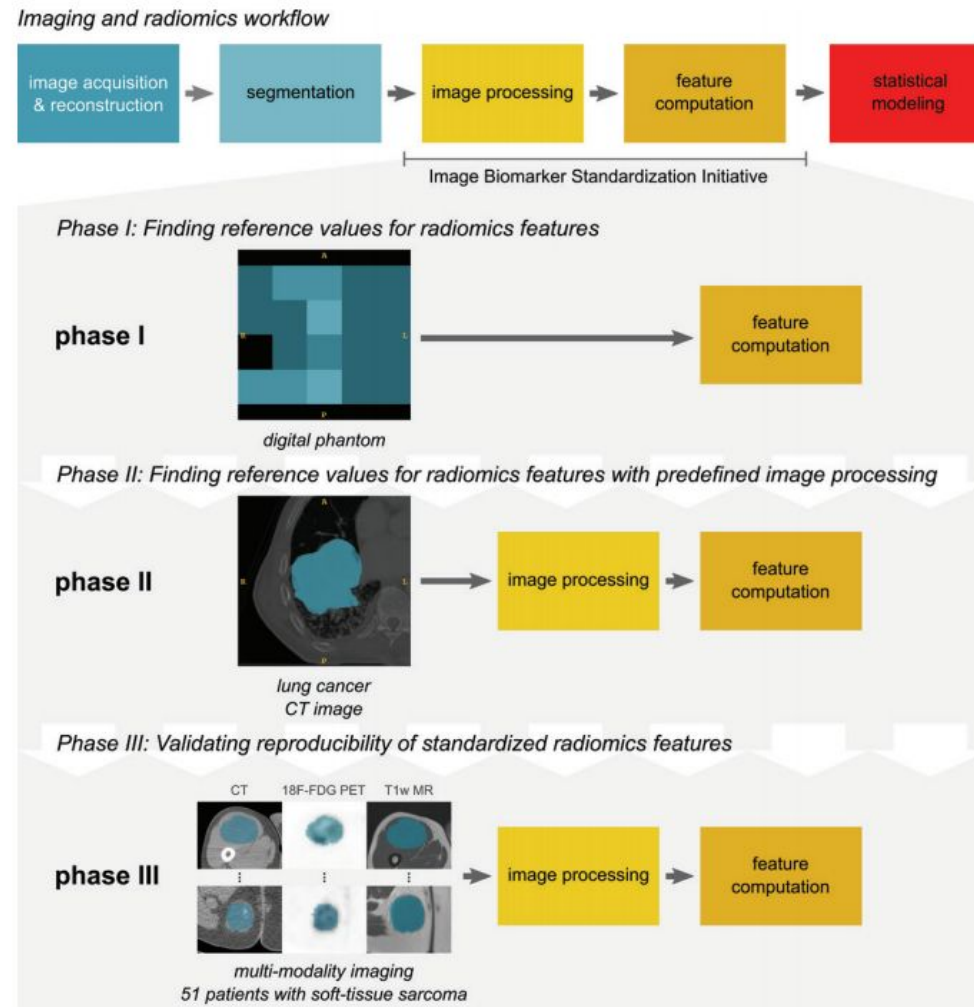
[pyradiomics.readthedocs.io/](http://pyradiomics.readthedocs.io/)



JJM van Griethuysen, A Fedorov, C Parmar, A Hosny, N Aucoin, V Narayan, RGH Beets-Tan, JC Fillion-Robin, S Pieper & HJWL Aerts

# Computational Radiomics System to Decode the Radiographic Phenotype

Cancer Research 2017

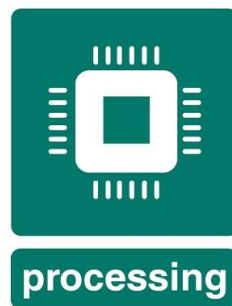


A Zwanenburg, M Vallières, MA Abdalah, HJWL Aerts, V Andrearczyk, A Apte, S Ashrafinia, S Bakas, RJ Beukinga, R Boellaard, M Bogowicz, et al.

## The Image Biomarker Standardization Initiative

Radiology 2019



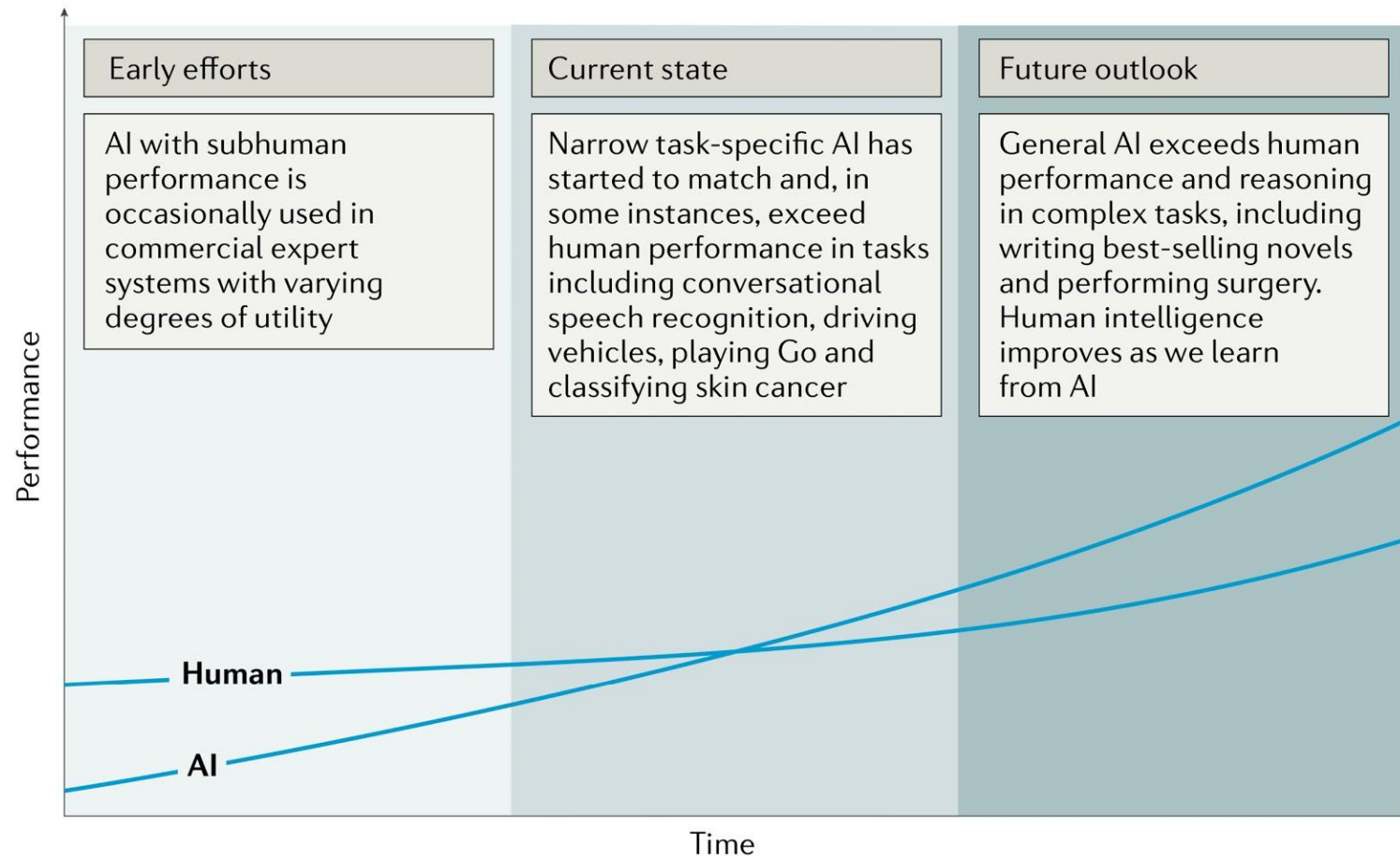


A Hosny, C Parmar, J Quackenbush, LZ Schwartz & HJWL Aerts

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## Artificial Intelligence in Radiology

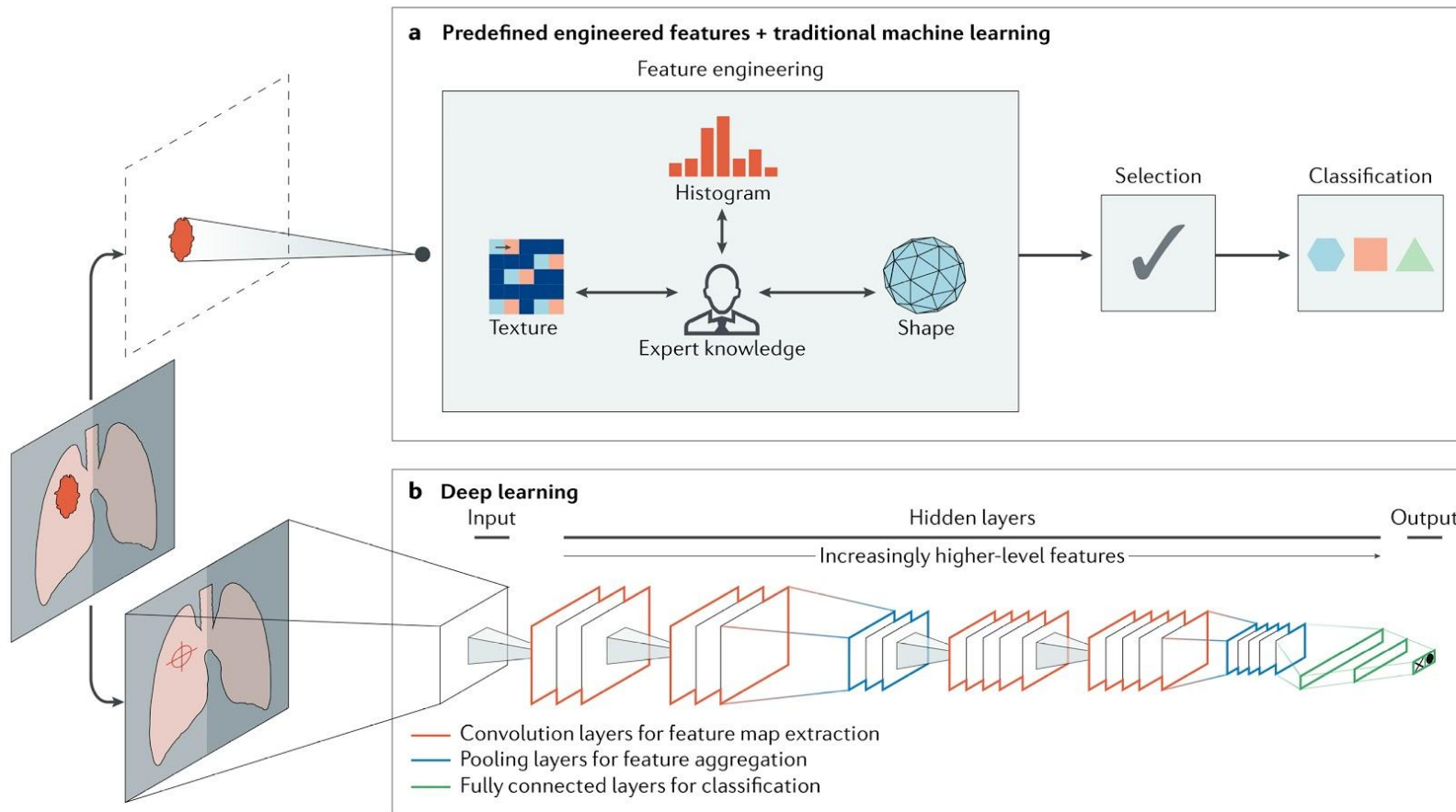
Nature Reviews Cancer 2018



A Hosny, C Parmar, J Quackenbush, LZ Schwartz & HJWL Aerts

## Artificial Intelligence in Radiology

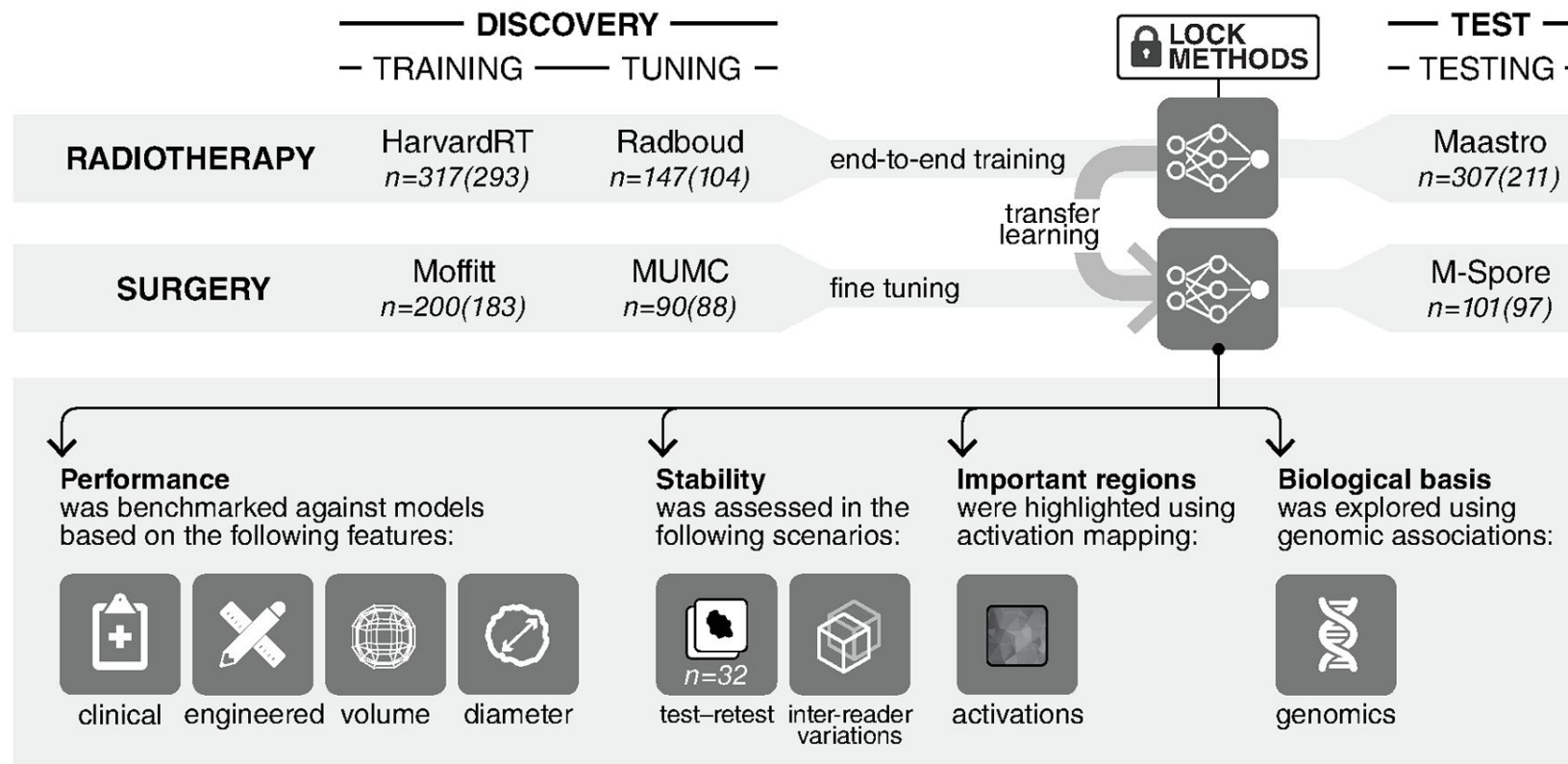
Nature Reviews Cancer 2018



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# Artificial Intelligence in Radiology

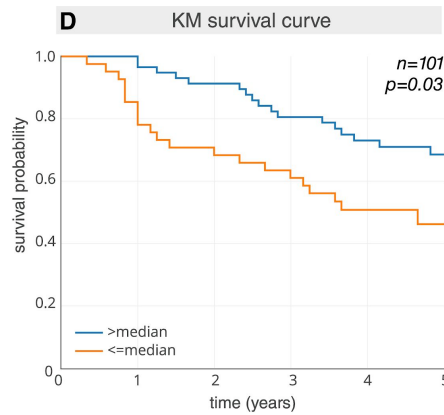
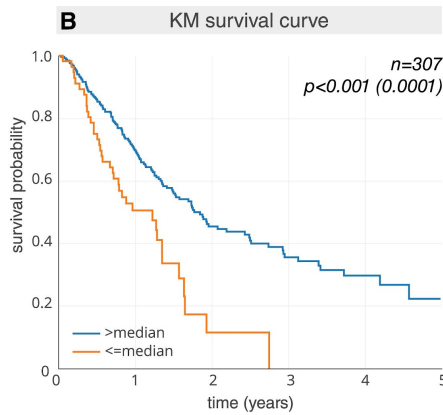
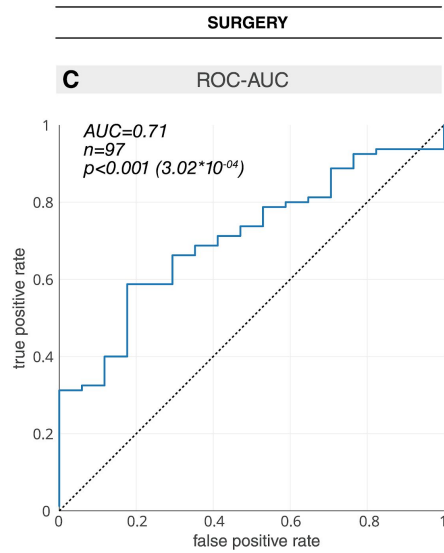
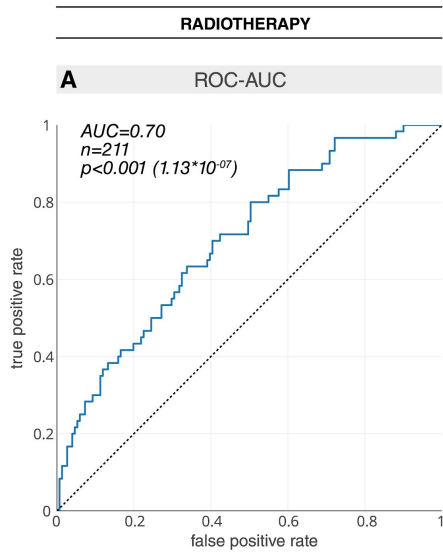
Nature Reviews Cancer 2018



A Hosny, C Parmar, T Coroller, P Grossmann, R Zeleznik, A Kumar, J Bussink, RJ Gillies, RH Mak & HJWL Aerts

# Deep Learning for Lung Cancer Prognostication: A Retrospective Multi-Cohort Radiomics Study

PLoS Medicine 2018

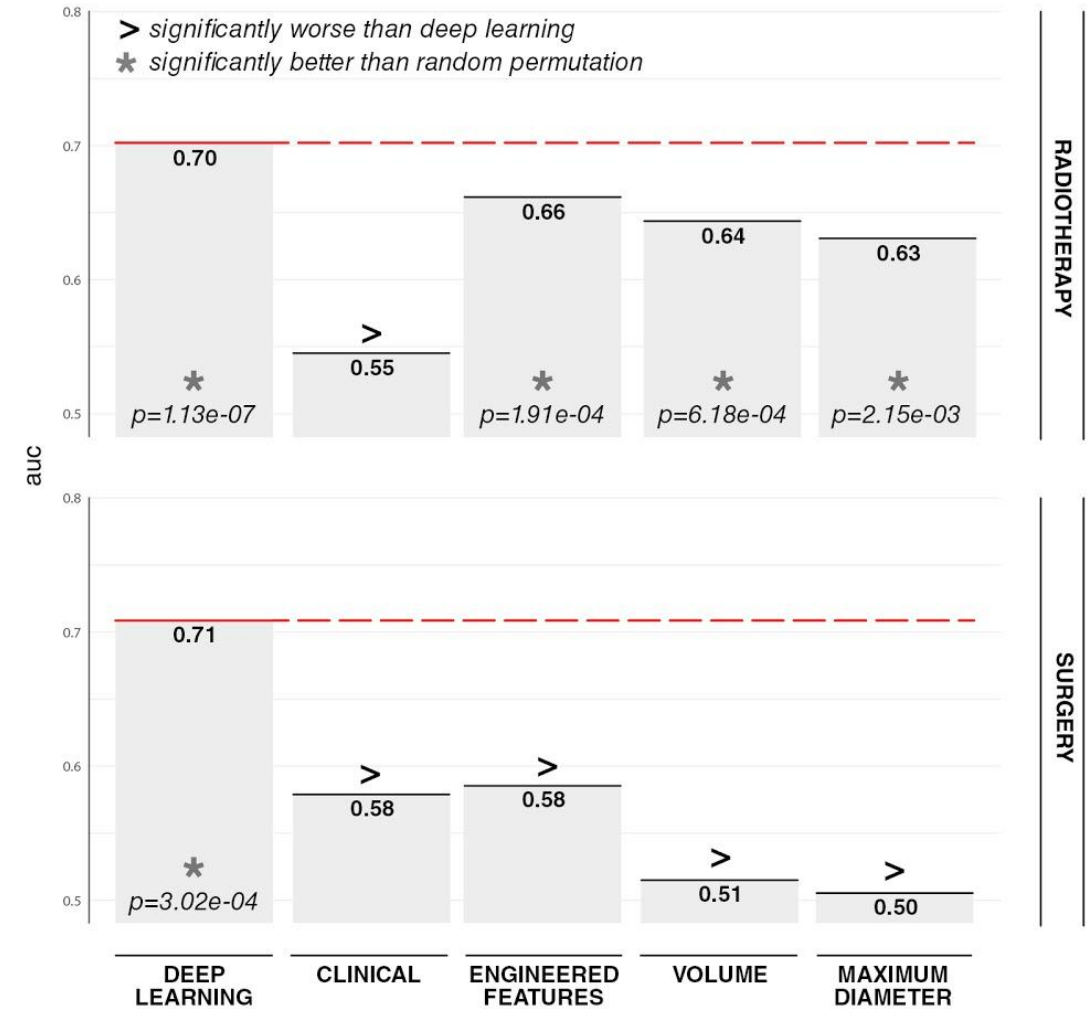
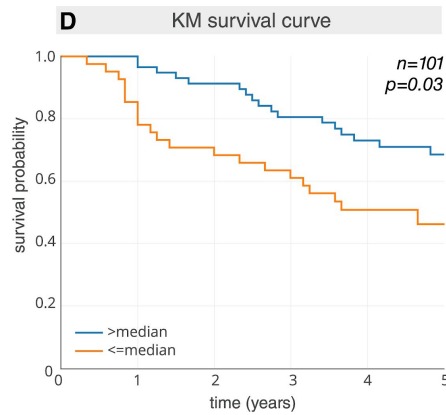
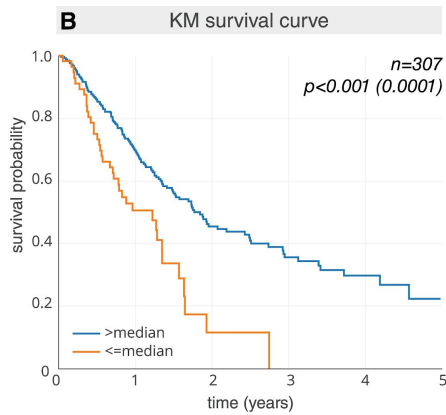
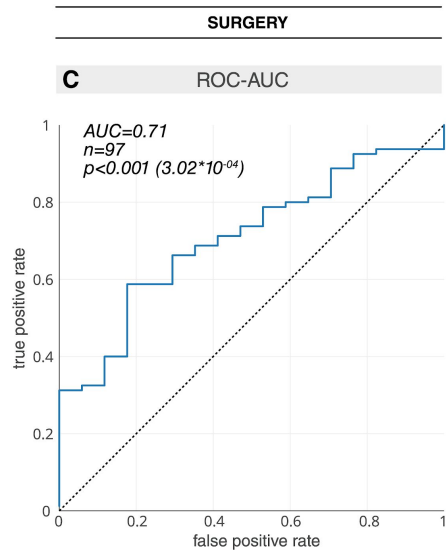
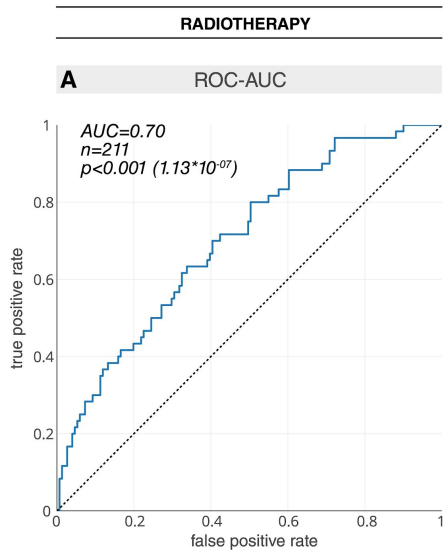


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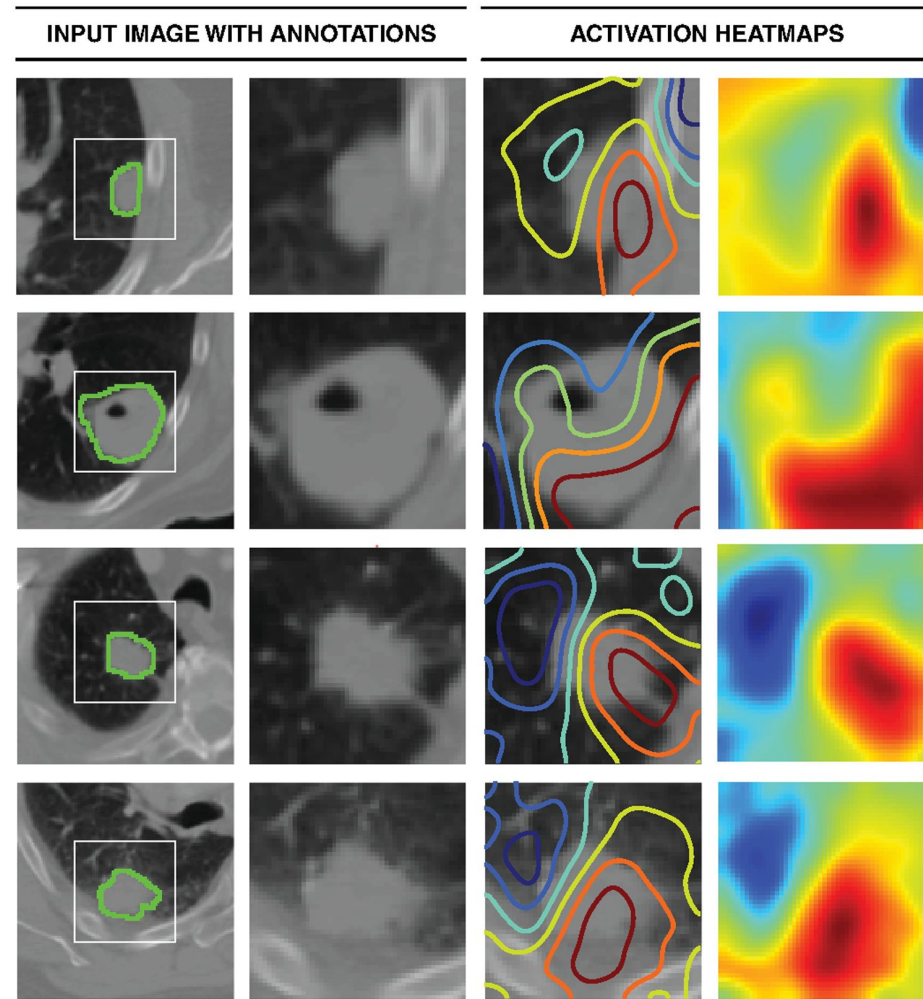




A Hosny, C Parmar, T Coroller, P Grossmann, R Zeleznik, A Kumar, J Bussink, RJ Gillies, RH Mak & HJWL Aerts

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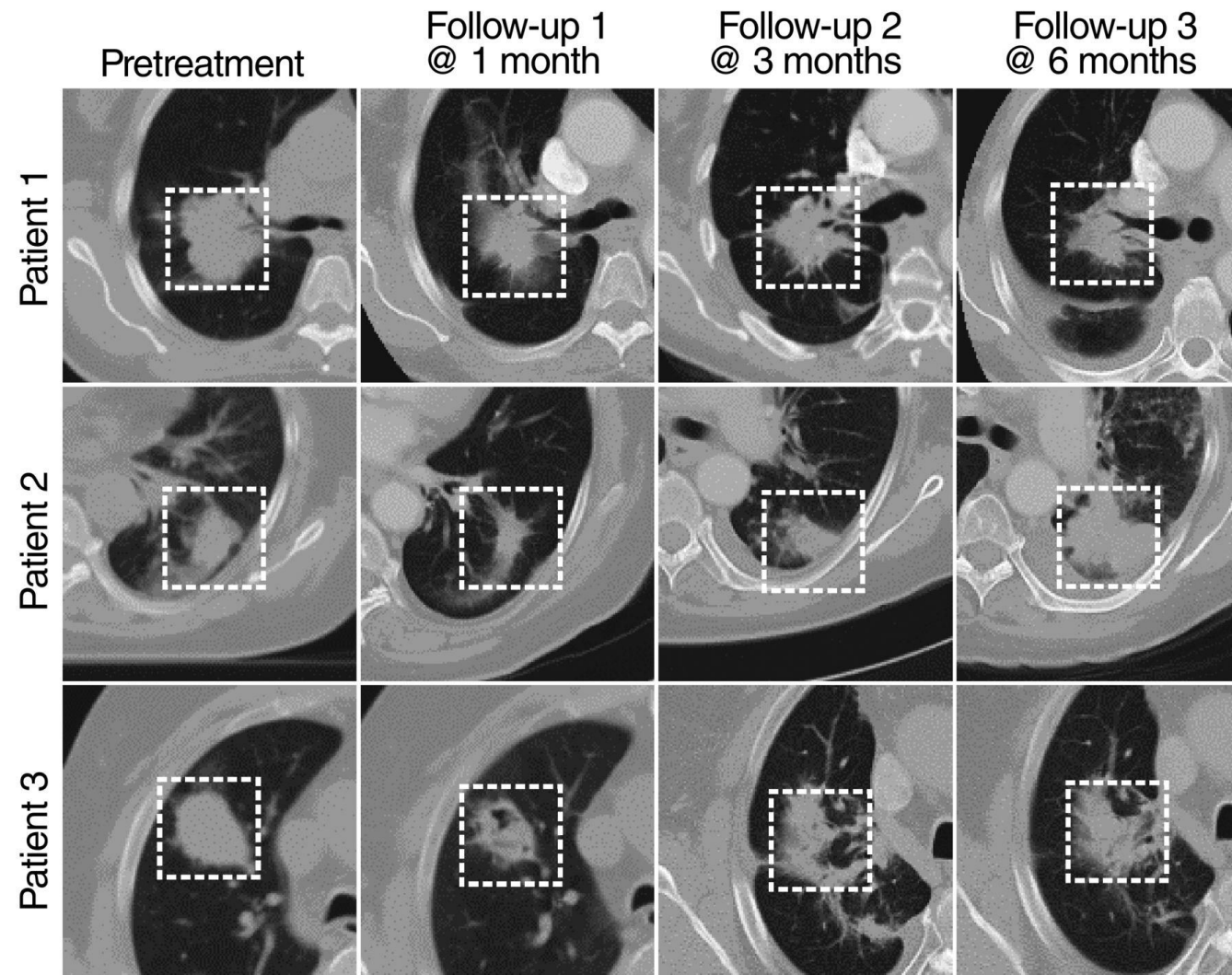
PLoS Medicine 2018



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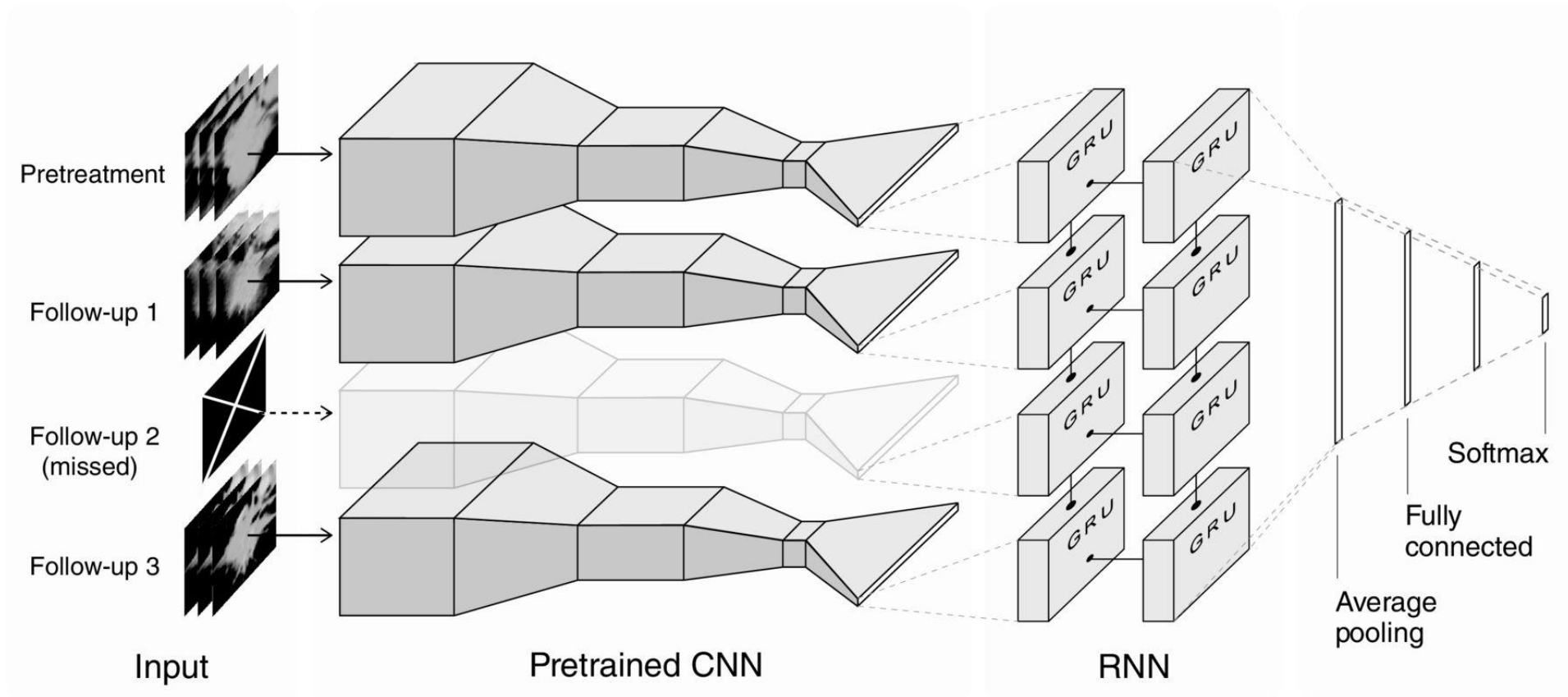
PLoS Medicine 2018



Y Xu, A Hosny, R Zeleznik, C Parmar, T Coroller, I Franko, RH Mak & HJWL Aerts

## Deep Learning Predicts Lung Cancer Treatment Response from Serial Medical Imaging

Clinical Cancer Research 2019

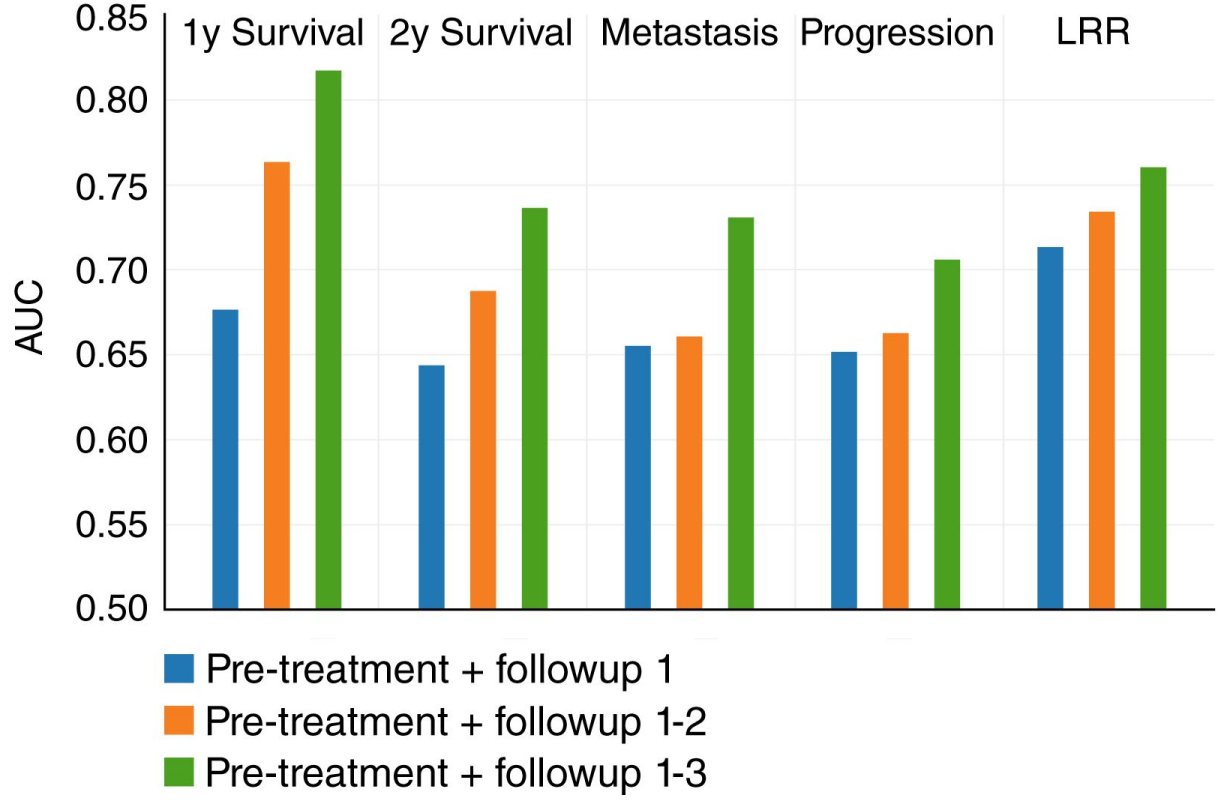
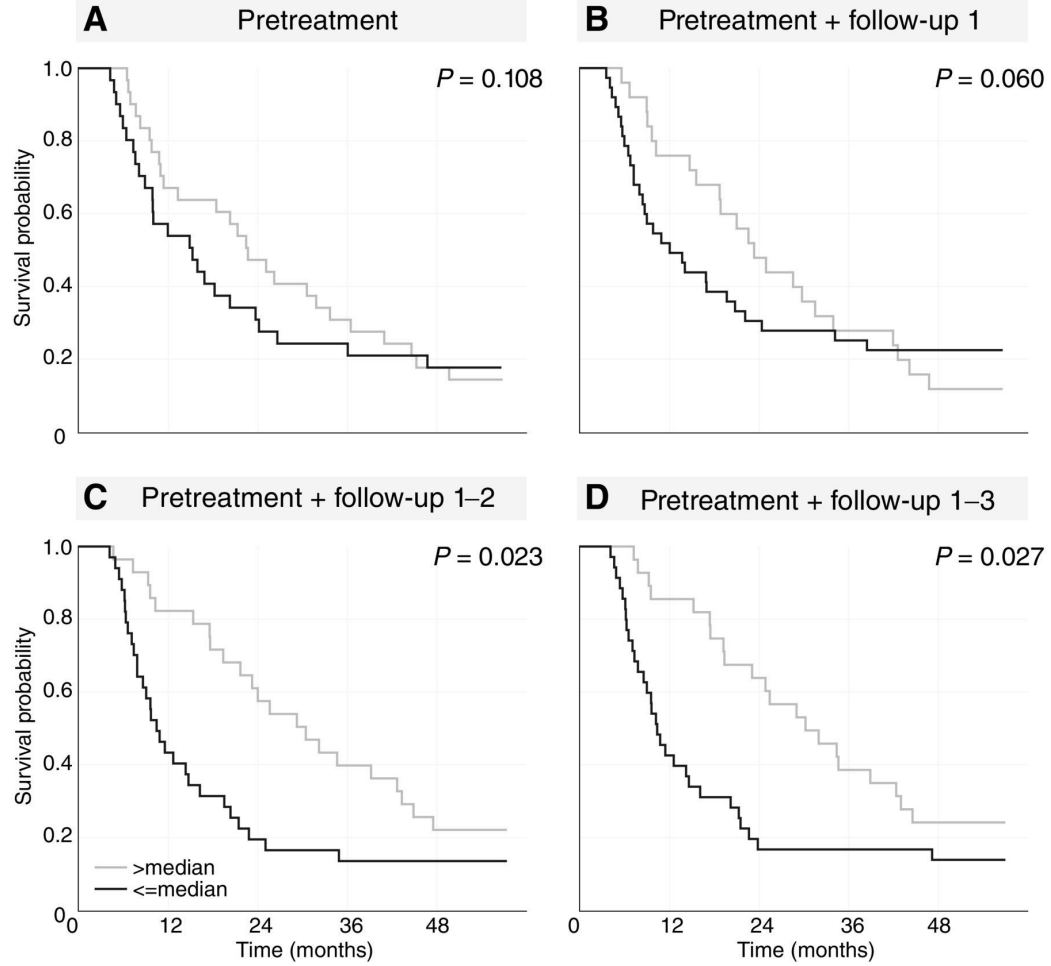


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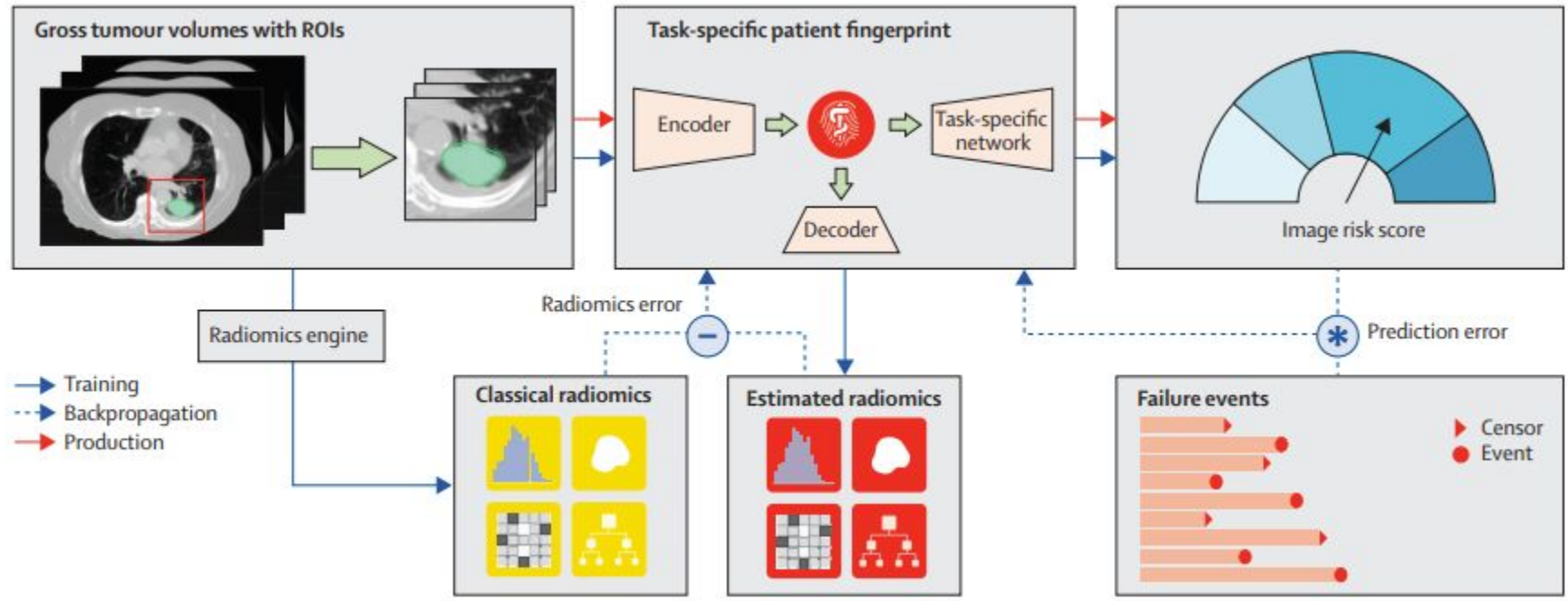
Supp. Figure 3



Y Xu, A Hosny, R Zeleznik, C Parmar, T Coroller, I Franko, RH Mak & HJWL Aerts

# Deep Learning Predicts Lung Cancer Treatment Response from Serial Medical Imaging

Clinical Cancer Research 2019



B Lou, S Doken, T Zhuang, D Wingerter, M Gidwani, N Mistry, L Ladic, A Kamen & ME Abazeed

# An Image-based Deep Learning Framework for Individualising Radiotherapy Dose

Lancet Digital Health 2019

In this study, the authors chose to identify handcrafted radiomics features as ground truth while comparing them to features identified by deep learning methods. The level of agreement between these two sets of features was then used as a cost function to train and optimise the predictive model. This method was understandably chosen as a means to provide a connection to the previous traditional radiomics landscape and greater interpretability. **However, we believe that deep learning can emerge as an independent methodology that does not need to rely on handcrafted radiomics to move forward.** Combining traditional radiomic features into deep learning models risks incorporating the aforementioned known human biases into the model. Additionally, **a combined approach does not address the interpretability problem since even most mathematically-derived handcrafted features capture uninterpretable imaging characteristics that cannot be discerned by the human eye.** Nevertheless, the challenges of traditional radiomics approaches such as lack of reproducibility and interpretability as well as over-fitting on small datasets will only be amplified in deep learning-driven prediction models of cancer outcome. Fortunately, interpretability of features learned through neural networks is an active area of research, while sharing and transparency initiatives are paving the way for larger curated cancer imaging repositories.

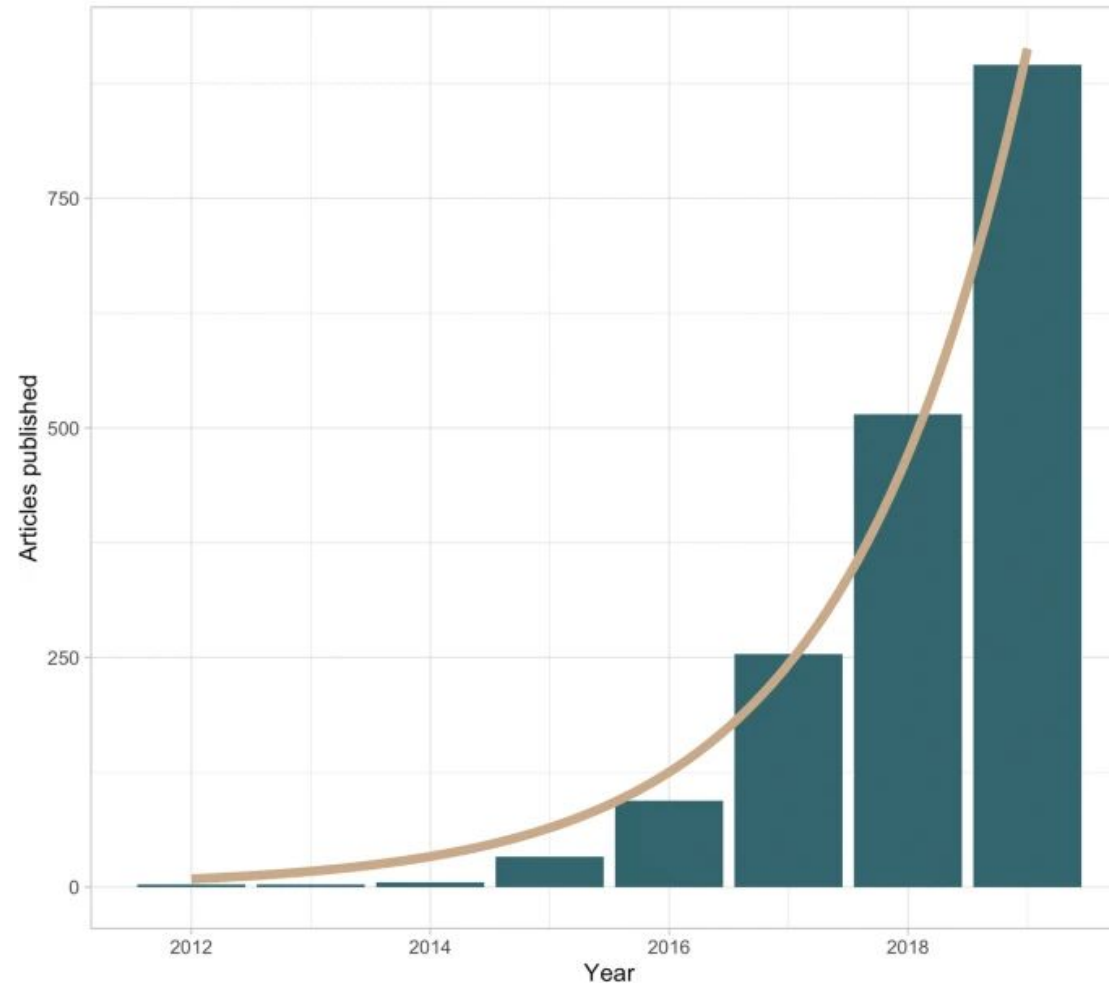
## Challenges

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Radiomics research over the years

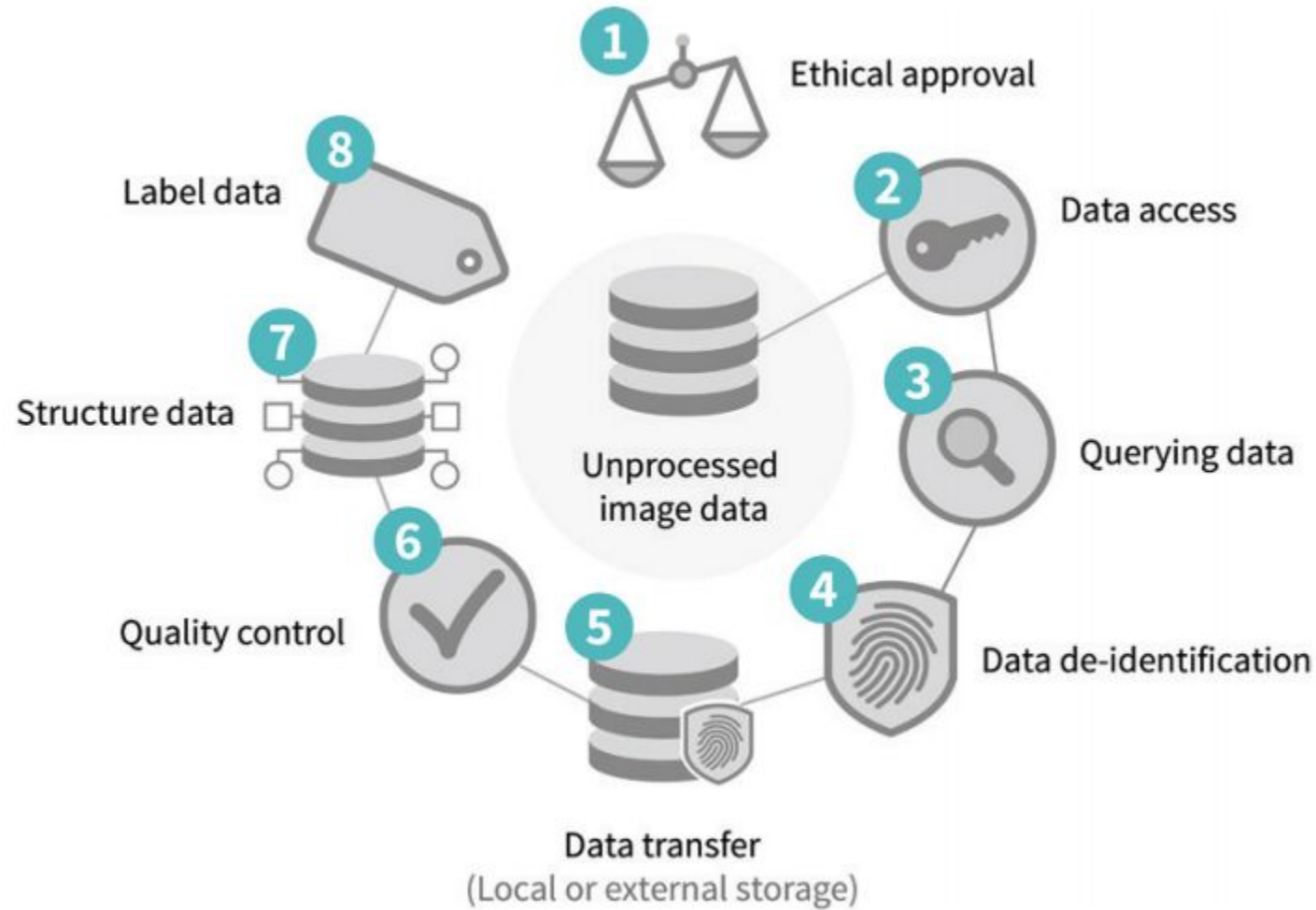
Data source: pubmed



DP Santos, M Dietzel & B Baessler

## A Decade of Radiomics Research: Are Images Really Data or Just Patterns in the Noise?

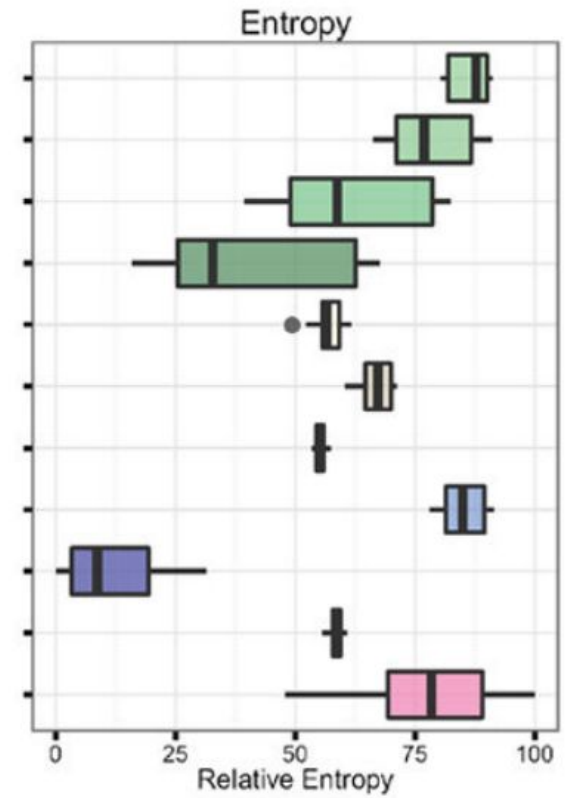
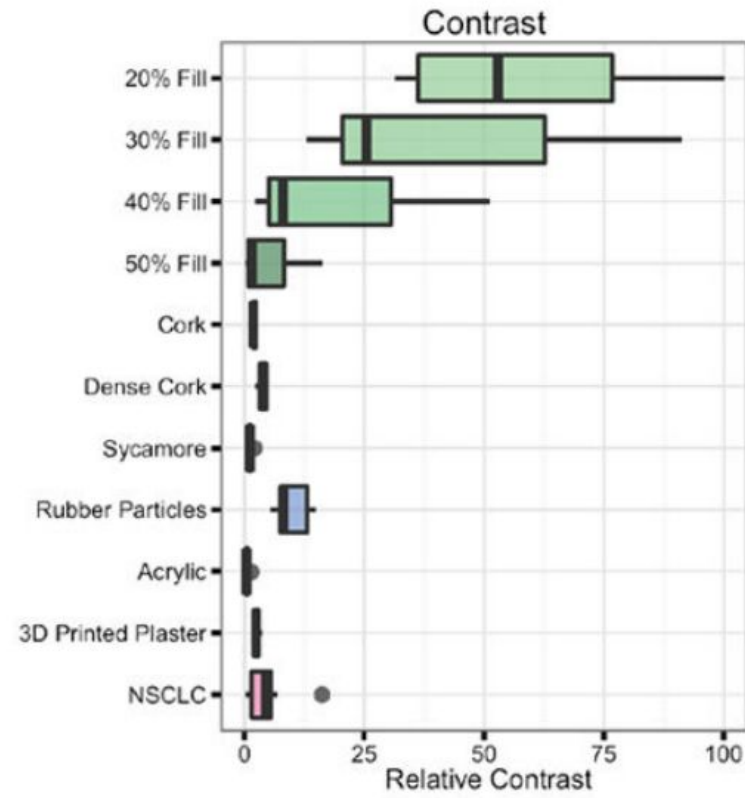
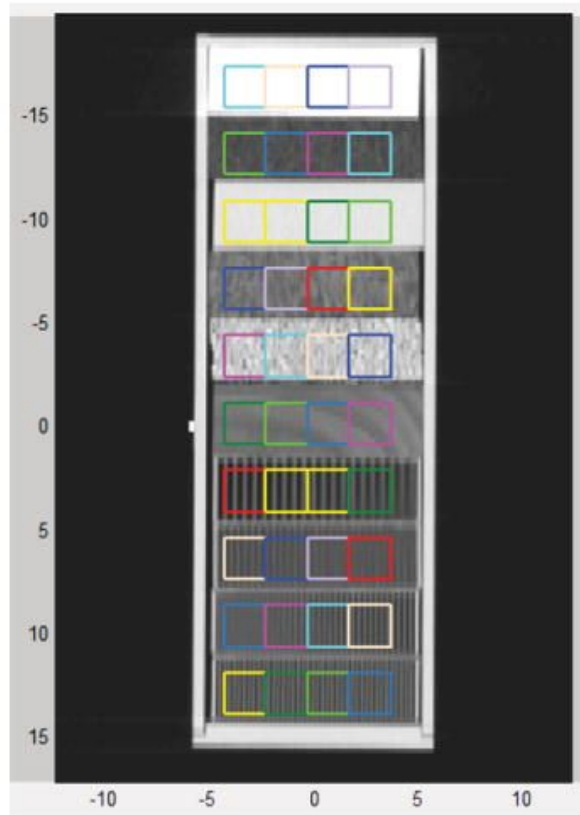
European Radiology 2021



MJ Willeminck , WA Koszek, C Hardell, J Wu, D Fleischmann, H Harvey, LR Folio, RM Summers, DL Rubin, MP Lungren

## Preparing Medical Imaging Data for Machine Learning

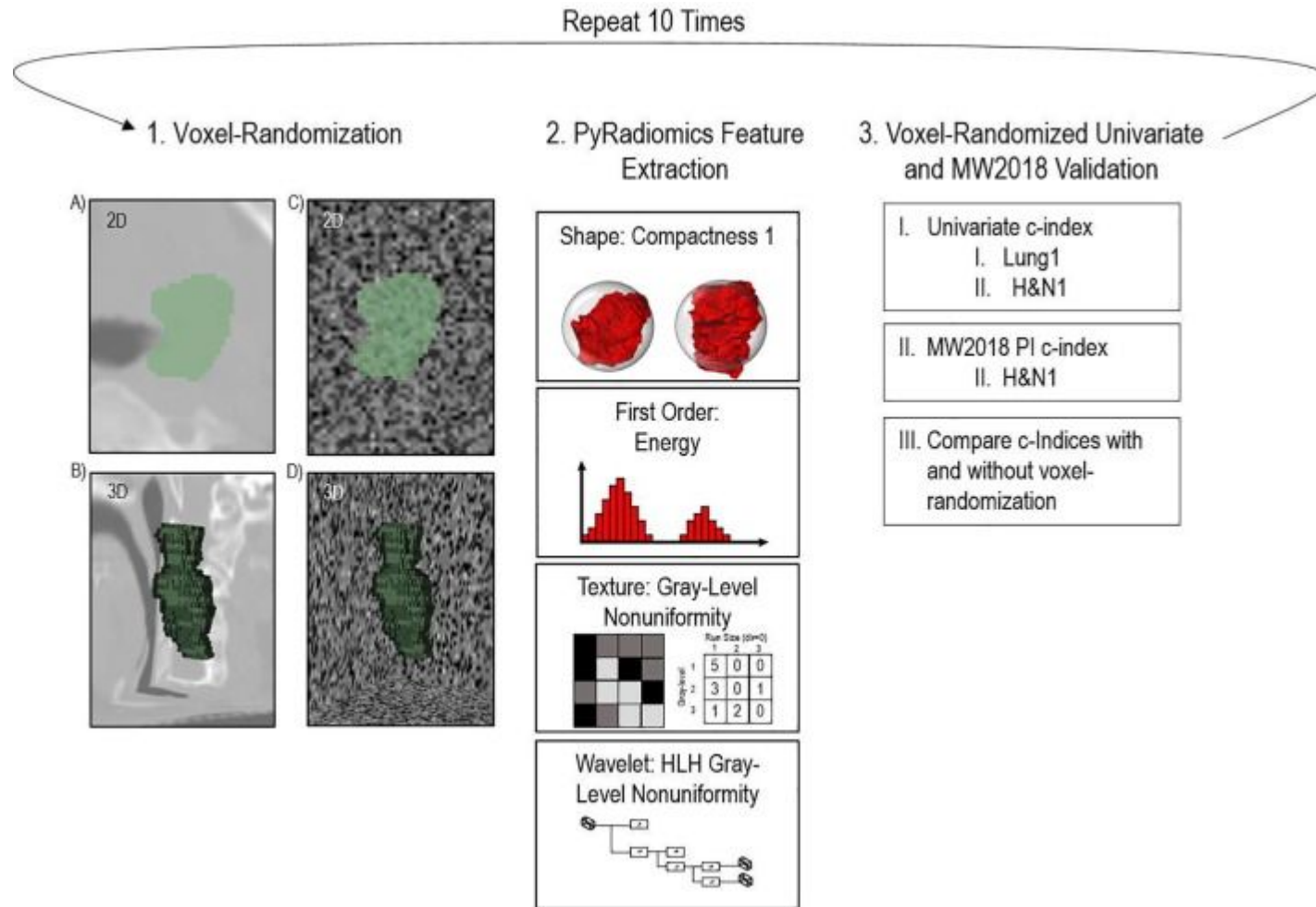
Radiology 2020



D Mackin, X Fave, L Zhang, D Fried, J Yang, B Taylor, E Rodriguez-Rivera, C Dodge, AK Jones & L Court

## Measuring CT Scanner Variability of Radiomics Features

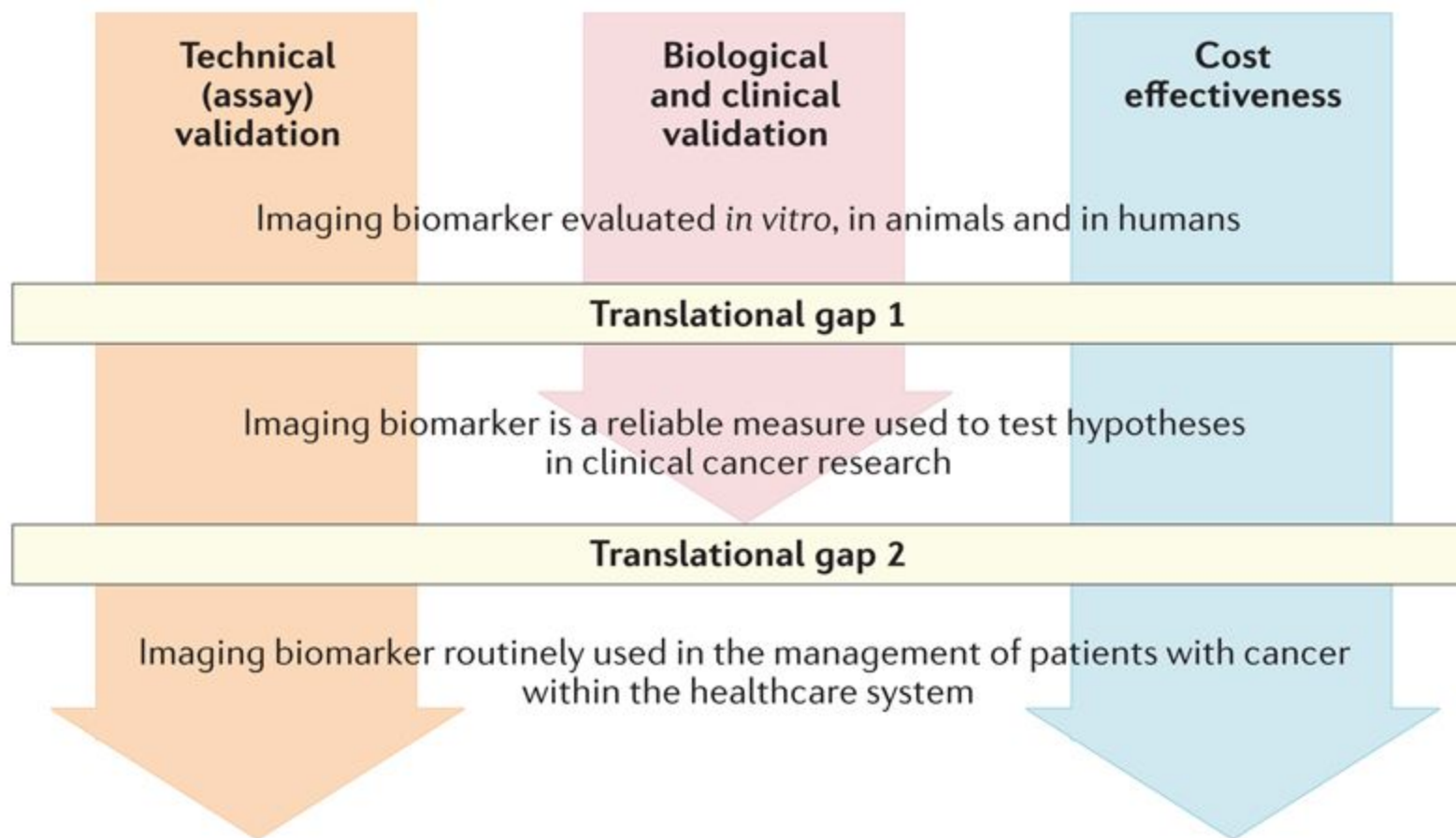
Investigative Radiology 2015



ML Welch, C McIntosh, B Haibe-Kains, MF Milosevic, L Wee, A Dekker, SH Huang, TG Purdie, B O'Sullivan, HJWL Aerts & DA Jaffray

## Vulnerabilities of Radiomic Signature Development: The Need for Safeguards

Radiotherapy and Oncology 2019



JPB O'Connor, EO Aboagye, JE Adams, HJWL Aerts, SF Barrington, AJ Beer, R Boellaard, SE Bohndiek, MBrady, GBrown, DL Buckley, et al.

## Imaging Biomarker Roadmap for Cancer Studies

Nature Reviews Clinical Oncology 2016

Thank you!

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