Clinical Data Science

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Voorspellen van Near Complete Response na Chemoradiatie *Indicaties voor een Boost ?*

Andre Dekker

Klinisch Fysicus | Hoogleraar Clinical Data Science

Maastro Clinic | Maastricht University | Maastricht UMC+

Radiotherapie bij rectum tumoren - Themadag Radiotherapie

Eindhoven | 05-03-2026 | 14:40 – 15:00

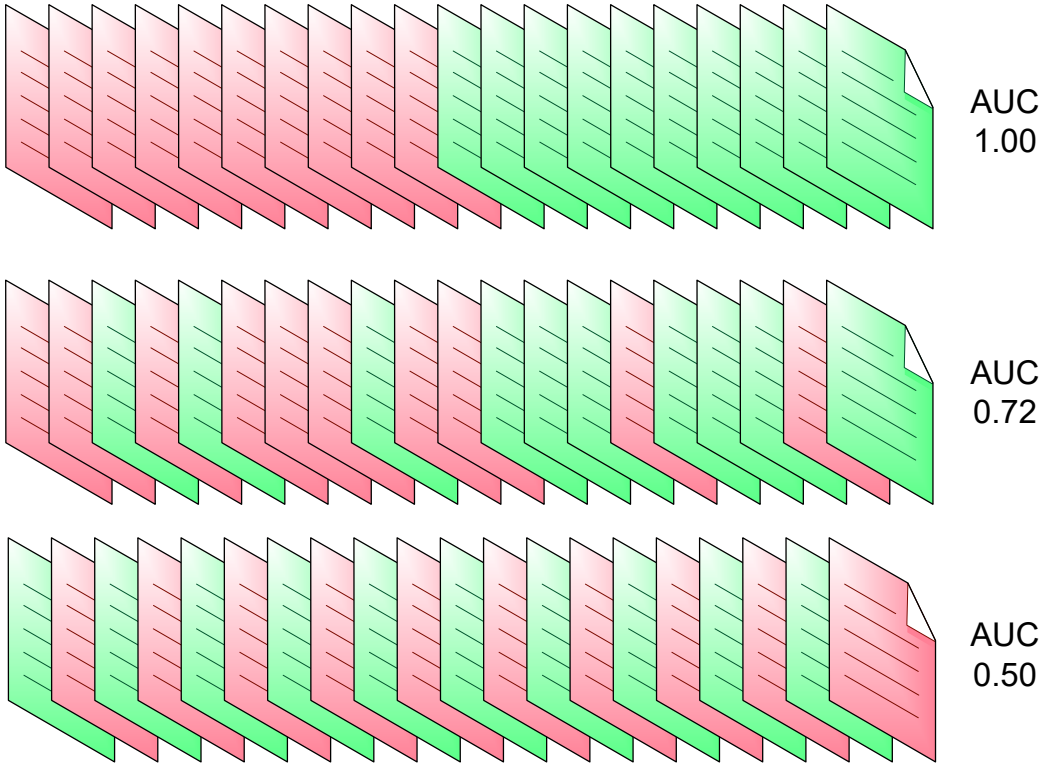
Belangen

- Onderzoekssamenwerkingen, waaronder financiering, consultancy en honoraria's voor sprekers
  - Farmaceutische industrie: Roche, Janssen, Bristol-Myers Squibb
  - MedTech/Data: Varian - Siemens, Philips, Sohard, Mirada Medical, IQVIA

- Externe adviesrollen
  - Zorg: MD Anderson Cancer Center, Peter Munk Cardiac Centre
  - Fondsen: Hanarth Fonds, NovoNordisk Foundation
  - Overig: Internationaal Atoom Energiea Antschap, Luxemburg National Research Fund

- Spin-offs en commerciële ondernemingen
  - Maastro Innovaties B.V.
  - Medical Data Works B.V.
  - Diverse patenten op het gebied van medisch machine learning en radiomici

AUC Metriek



Lagere kans op (n)CR Hogere kans op (n)CR

Werkelijke (n)CR

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Wat is een goede AUC?

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Radiotherapy and Oncology 144 (2020) 148–151

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Short Communication

On the limitations of the area under the ROC curve for NTCP modelling

Emanuel Bahn [a,b,c,d,*], Markus Alber [a,b,c]

[a] Department of Radiation Oncology, Heidelberg University Hospital, Heidelberg, Germany; [b] Heidelberg Institute of Radiation Oncology (HIRO); [c] National Center for Tumor Diseases (NCT); and [d] Clinical Cooperation Unit Radiation Oncology, German Cancer Research Center (DKFZ)

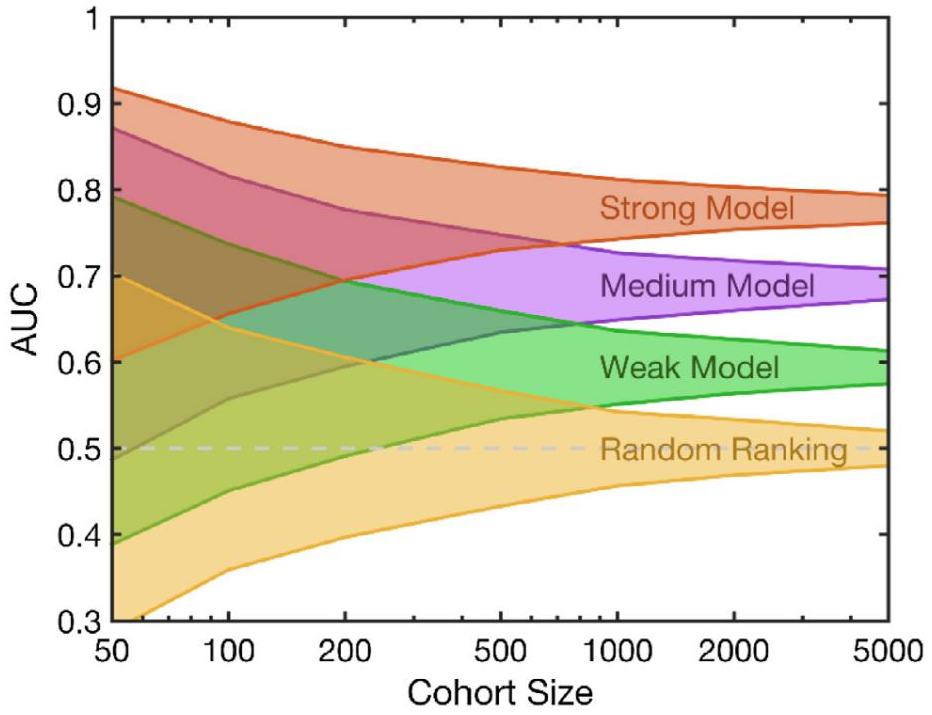

Fig. 2. 95 % Confidence intervals of AUC vs cohort size for three cohort NTCP distributions. Mean AUC: 0.59 (weak model), 0.69 (medium model), 0.78 (strong model), 0.50 (random ranking model).

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Discriminatie: ROC & AUC uitgelegd

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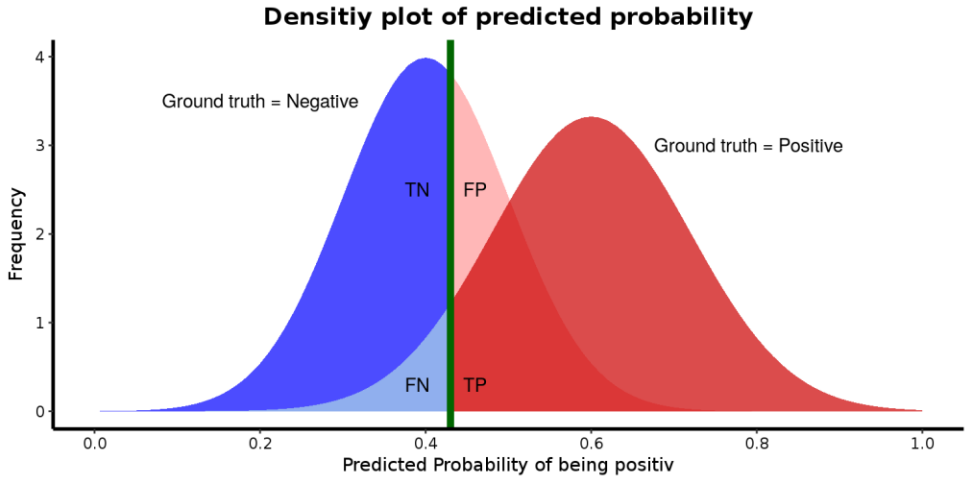
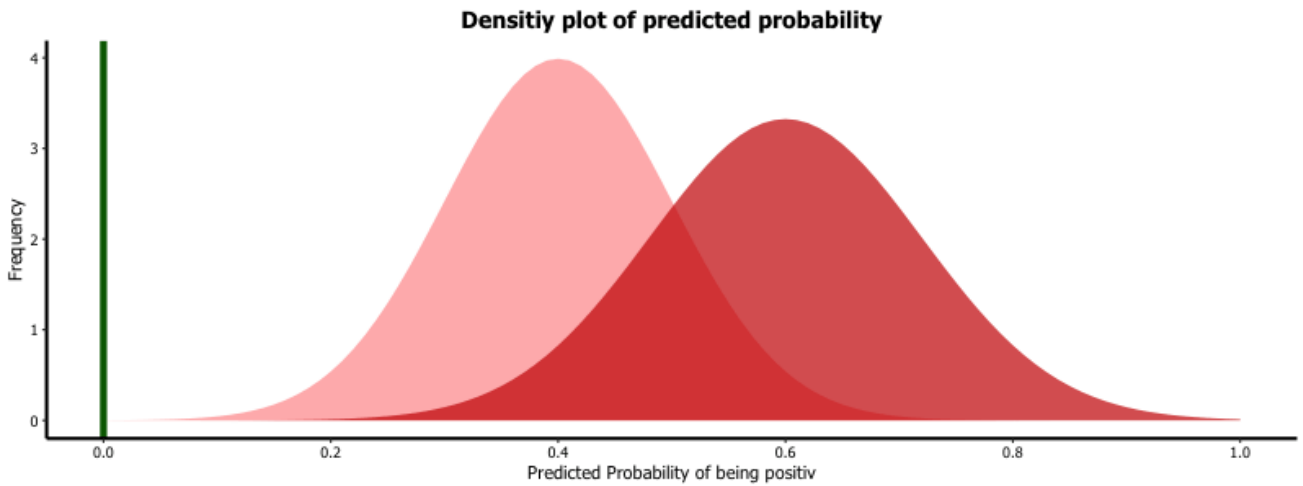
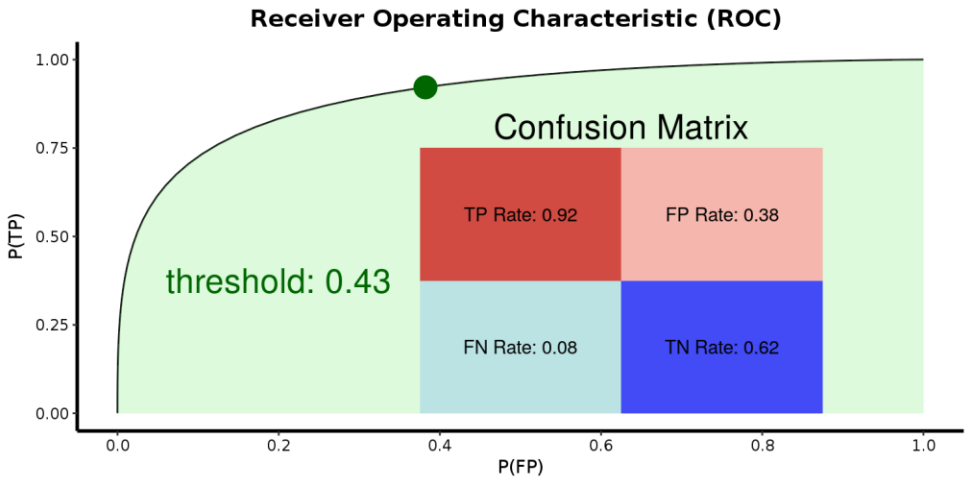
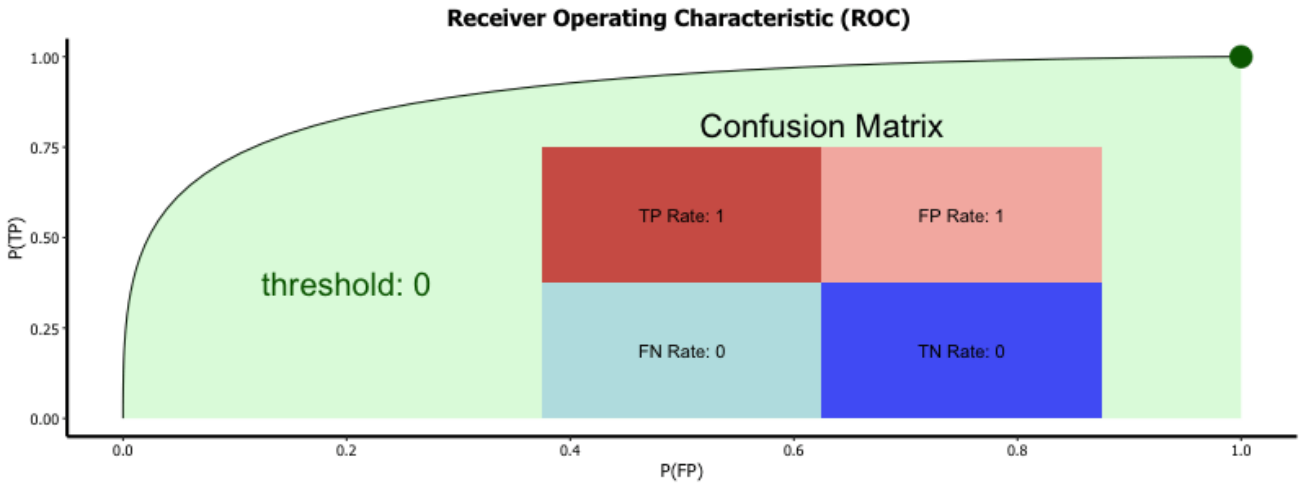


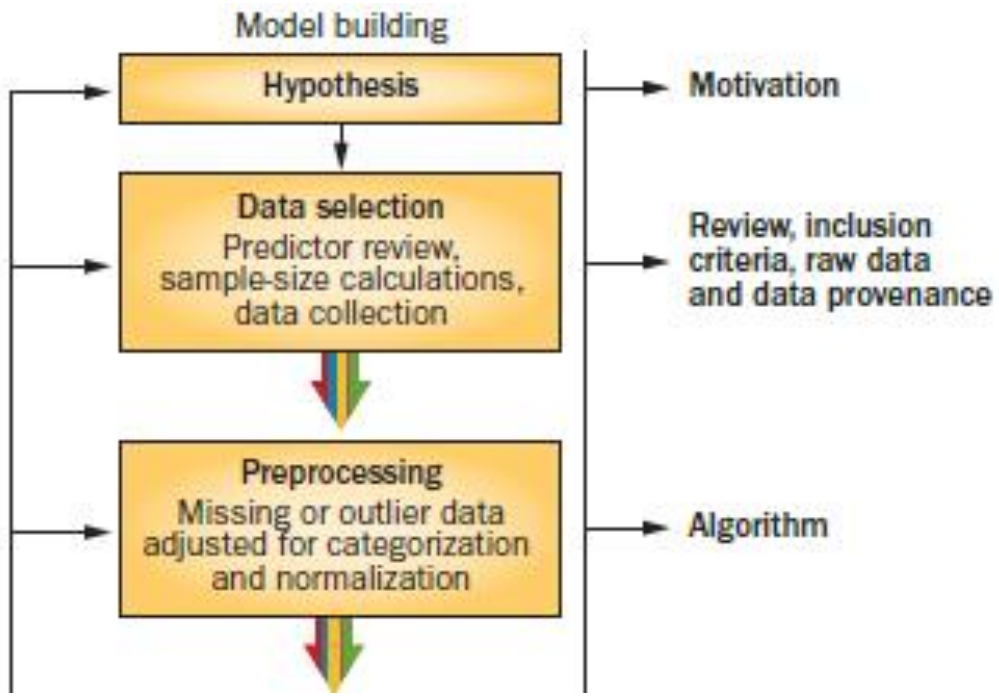


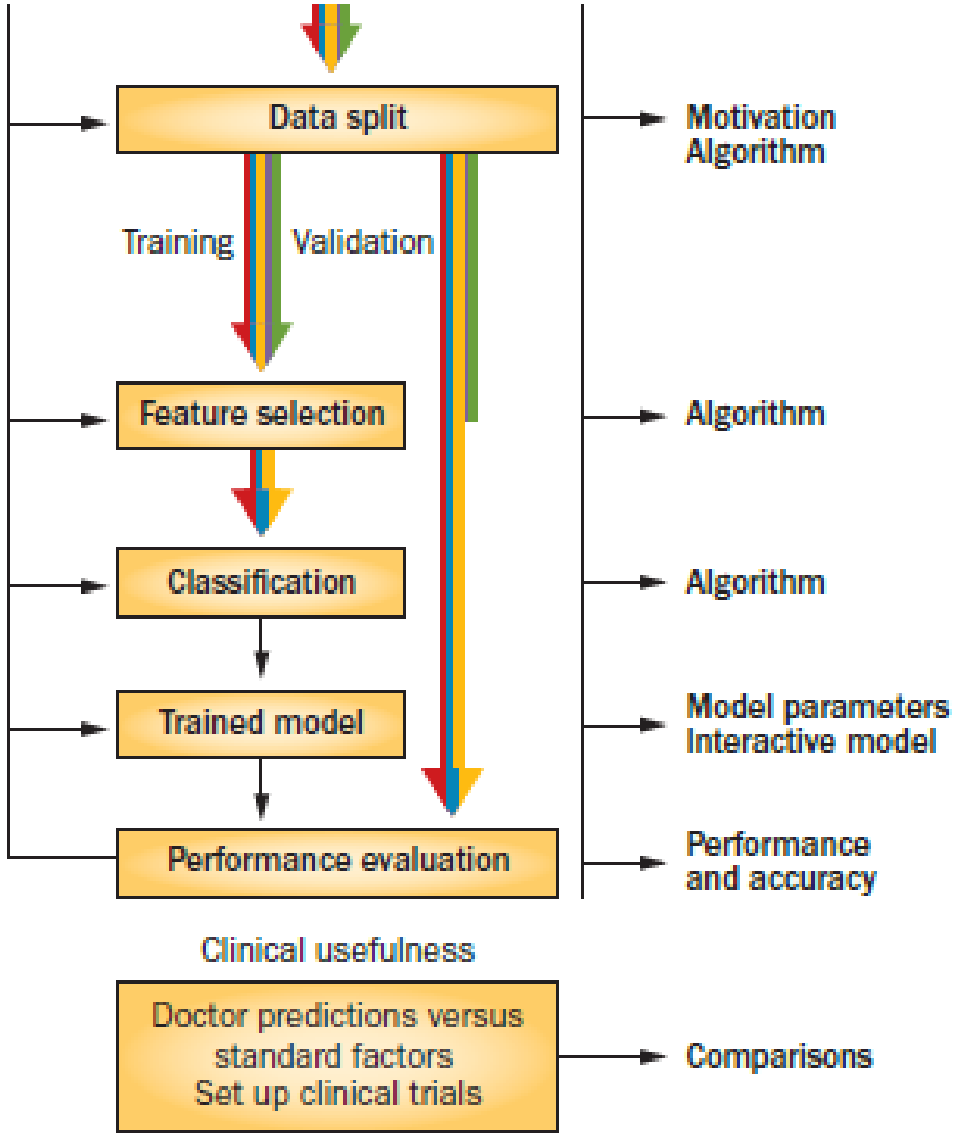




https://www.kaggle.com/nappon/animation-confusion-matrix-and-roc-interplay

Algemene AI-(model)benadering



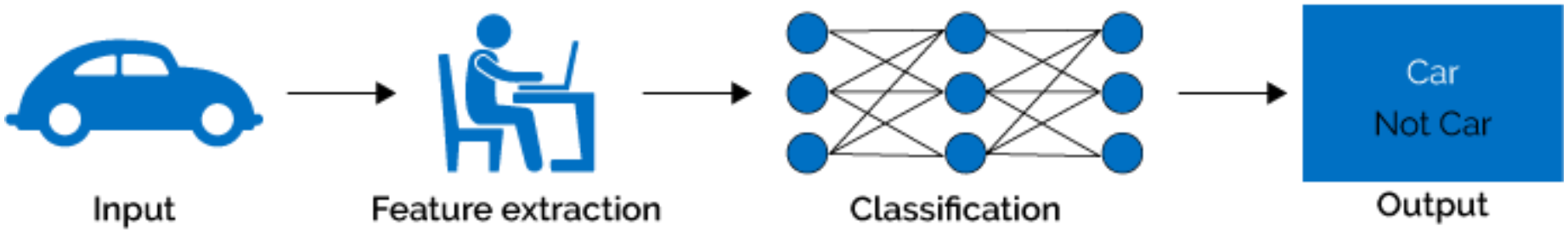


Predicting outcomes in radiation oncology —multifactorial decision support systems

Philippe Lambin, Ruud G. P. M. van Stiphout, Maud H. W. Starmans, Emmanuel Rios-Velazquez, Georgi Nalbantov, Hugo J. W. L. Aerts, Erik Roelofs, Wouter van Elmpt, Paul C. Boutros, Pierluigi Grano Vincenzo Valentini, Adrian C. Begg, Dirk De Ruysscher and Andre Dekker

Nat. Rev. Clin. Oncol. 10, 27–40 (2013) doi:10.1038/nrclinonc.2012.196

Machine Learning



Oren

Ogen

Vacht

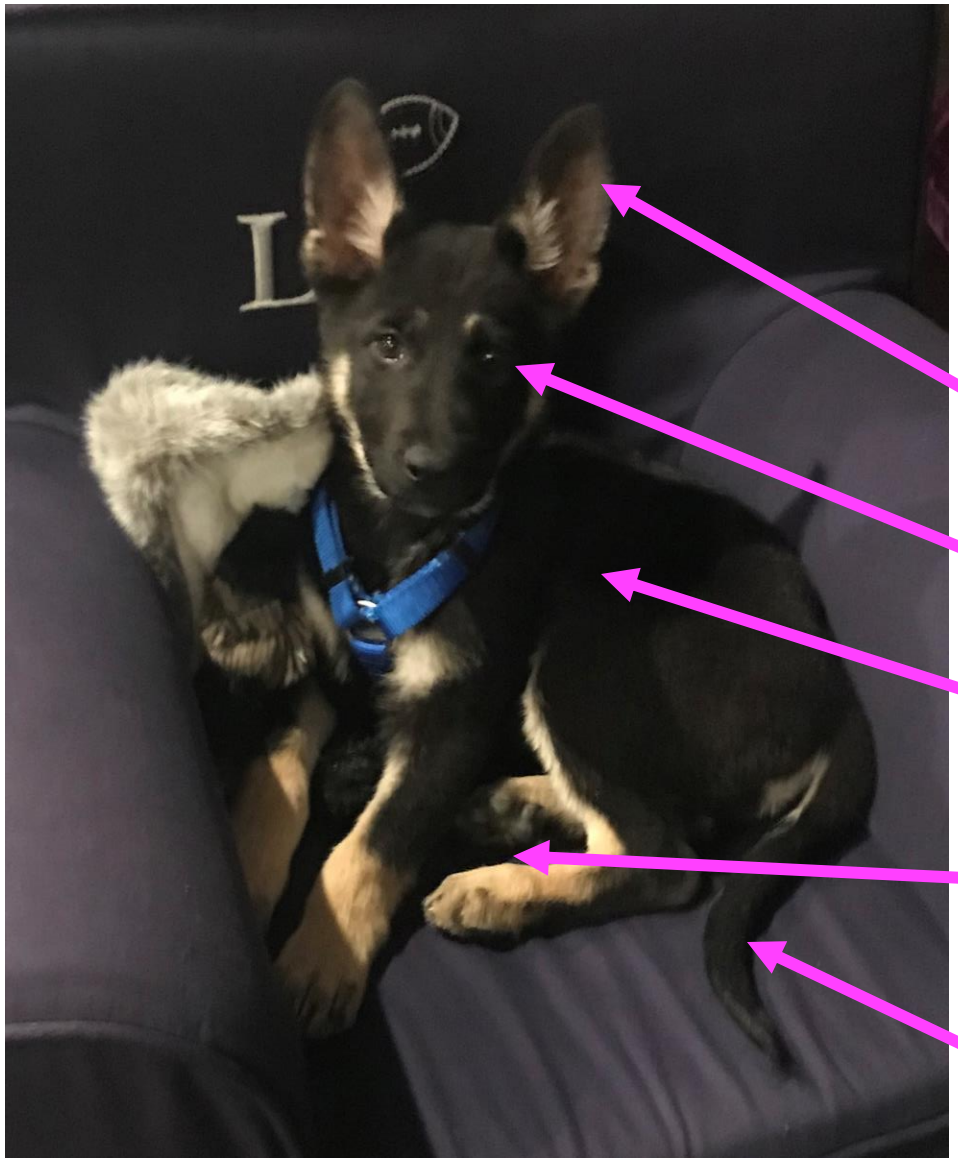
Poten

Staart

Kat

Slide met dank aan Kristy Brock

Machine Learning



Oren

Ogen

Vacht

Poten

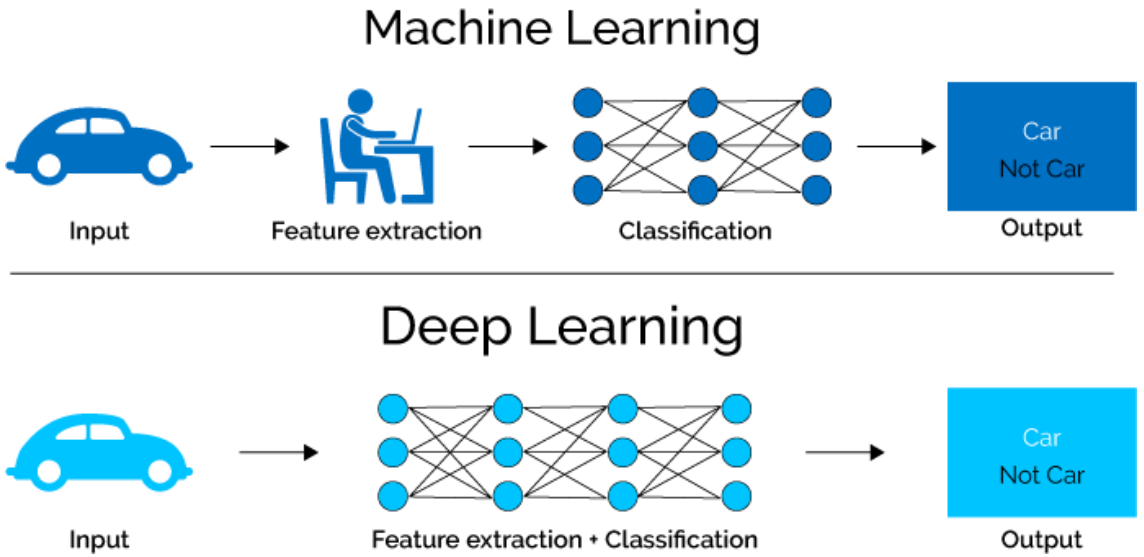
Staart

GEEN KAT!

Kat 97%

Slide (en hond) met dank aan Kristy Brock

Deep Learning – Human out of the loop



Slide met dank aan Kristy Brock

Balans tussen begrijpelijkheid en performance

Table 3 | Comparisons between human evaluations and different types of AI approaches

Approaches	Model comprehensibility	Performance	Reproducibility	Dependency on prior knowledge	Development and training costs[a]	Running costs	Around-the-clock availability	Update costs
Human evaluation	High	Moderate or high	Moderate	High	High	High	Low	High
Rule-based algorithms	High	Moderate or high	High	High	Moderate or high	Low	High	High
Feature-based machine-learning methods	Moderate or high	Moderate or high	High	Moderate[b]	Moderate	Low	High	Moderate[c]
Deep artificial neural networks	Low or moderate	High	High	Low	Moderate	Low	High	Low

Typisch: Simpele modellen voor voorspellen van uitkomst (makkelijk te begrijpen)

Nat Biomed Eng 2018;2:719

Andersom denken

- Als delen het probleem is: deel de data niet

- Als je de data niet naar het onderzoek kunt brengen.
- Dan moet je het onderzoek naar de data brengen

- Uitdagingen
  - De onderzoeksapplicatie moet gedistribueerd worden(treinen en spoor)
  - De data moet begrijpelijk zijn voor een applicatie (en dus niet alleen voor een mens) -> FAIR-data stations

PERSONAL HEALTH TRAIN

Wilkinson, DOI: 10.1038/sdata.2016.18

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euroCAT voorbeeld

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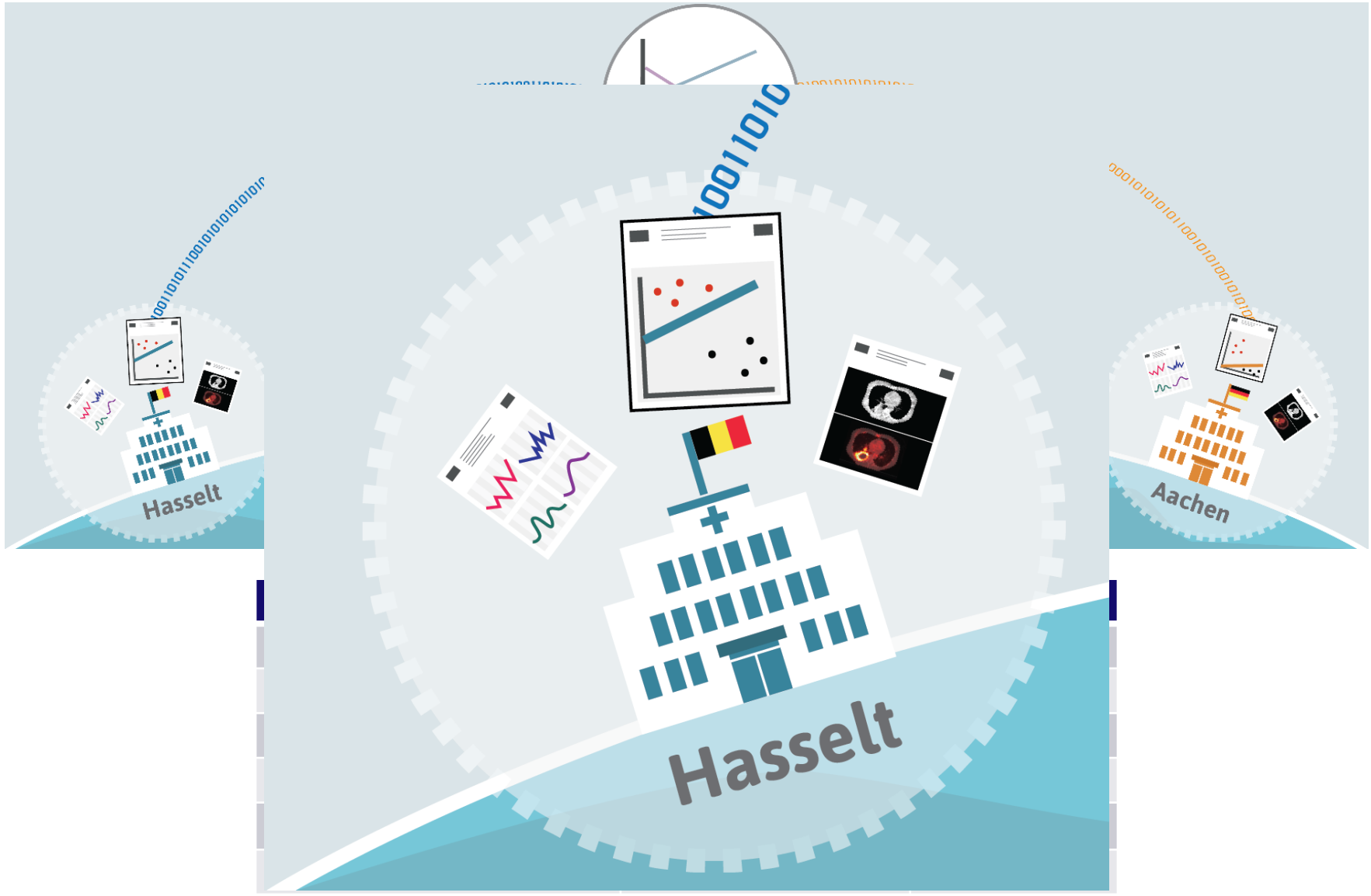
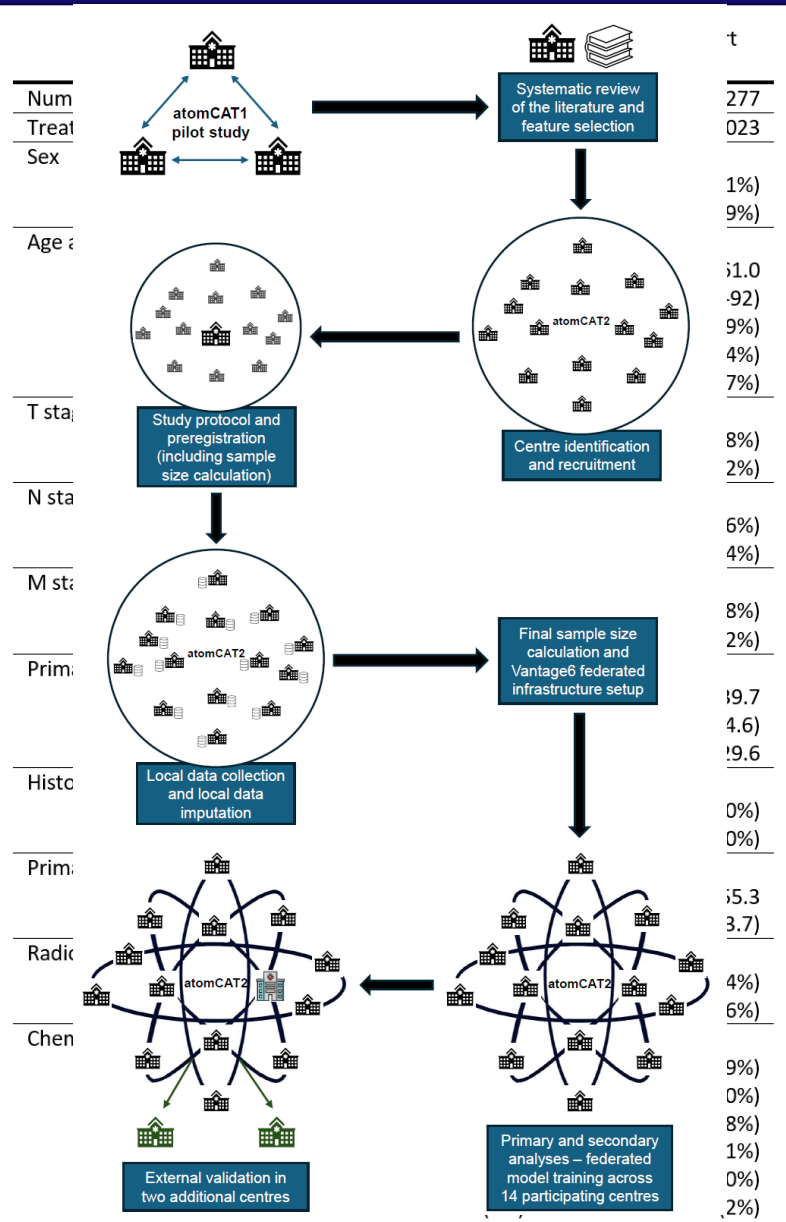


Anuskanker

Federated learning with real-world data: An international multi-centre study to develop and validate prognostic models for anal cancer

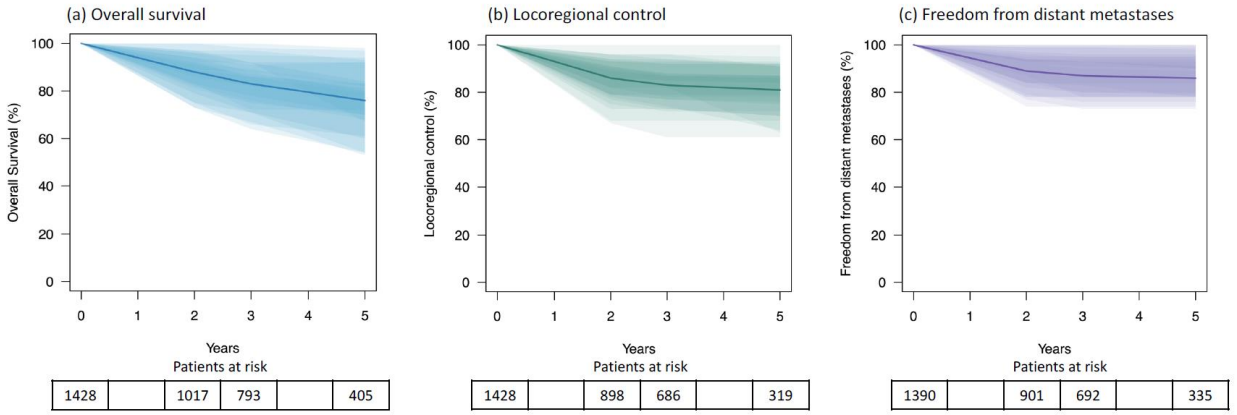
atomCAT2 16 kankercentra
Leeds, VK
- Hull, VK
- Cardiff, VK
- Manchester, VK
- Oxford, VK
- Cambridge, VK
- Oslo, Noorwegen
- Maastricht, Nederland
- Amsterdam, Nederland
- Nicosia, Cyprus
- Lissabon, Portugal
- Rome, Italië
- Poznań, Polen
- Aken, Duitsland
- Liverpool, Australië

1605 patiënten



Geaccepteerd voor publicatie in Nature Communications (Dec 2025)

Anuskanker



	Overall survival	Locoregional control	Freedom from distant metastases
Mean global model c-index	0.68	0.71	0.69
Mean leave-one-centre-out validation c-index	0.67	0.69	0.66
		Hazard ratio (95% CI)	
Nodal involvement (N+ relative to N0)	1.45 (1.11-1.89)	1.24 (0.92-1.68)	2.09 (1.42-3.08)
T stage (T3-4 relative to T1-2)	1.42 (1.07-1.89)	1.46 (1.05-2.03)	1.18 (0.80-1.74)
Sex (Female relative to male)	0.65 (0.51-0.83)	0.56 (0.43-0.73)	0.82 (0.58-1.16)
Age at start of radiotherapy (per 10 years)	1.20 (1.07-1.34)	1.08 (0.96-1.22)	1.00 (0.86-1.16)
Gross tumour volume (cm^3)	2.02 (1.47-2.76)	2.47 (1.73-3.53)	2.14 (1.40-3.27)
Prescribed dose to primary tumour (log_{10} EQD2, per 10 Gy)	0.96 (0.71-1.29)	1.17 (0.82-1.67)	1.21 (0.79-1.86)
Histology (Basaloid SCC relative to SCC)	0.88 (0.61-1.28)	0.64 (0.39-1.06)	1.04 (0.64-1.69)
Radiotherapy technique (IMRT/VMAT relative to 3D-CRT)	0.96 (0.67-1.39)	1.55 (0.91-2.64)	N/A
Chemotherapy regimen (all relative to no chemotherapy)			
Mitomycin-based	0.35 (0.23-0.53)	0.67 (0.35-1.25)	0.59 (0.28-1.23)
Cisplatin-based	0.32 (0.11-0.92)	0.72 (0.22-2.30)	0.80 (0.21-3.09)
Other chemotherapy	0.81 (0.42-1.56)	0.83 (0.30-2.27)	0.94 (0.31-2.92)

Geaccepteerd voor publicatie in Nature Communications (Dec 2025)

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Voorspellen van de kans op CR

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Radiotherapy and Oncology 113 (2014) 215–222

Contents lists available at ScienceDirect

Radiotherapy and Oncology

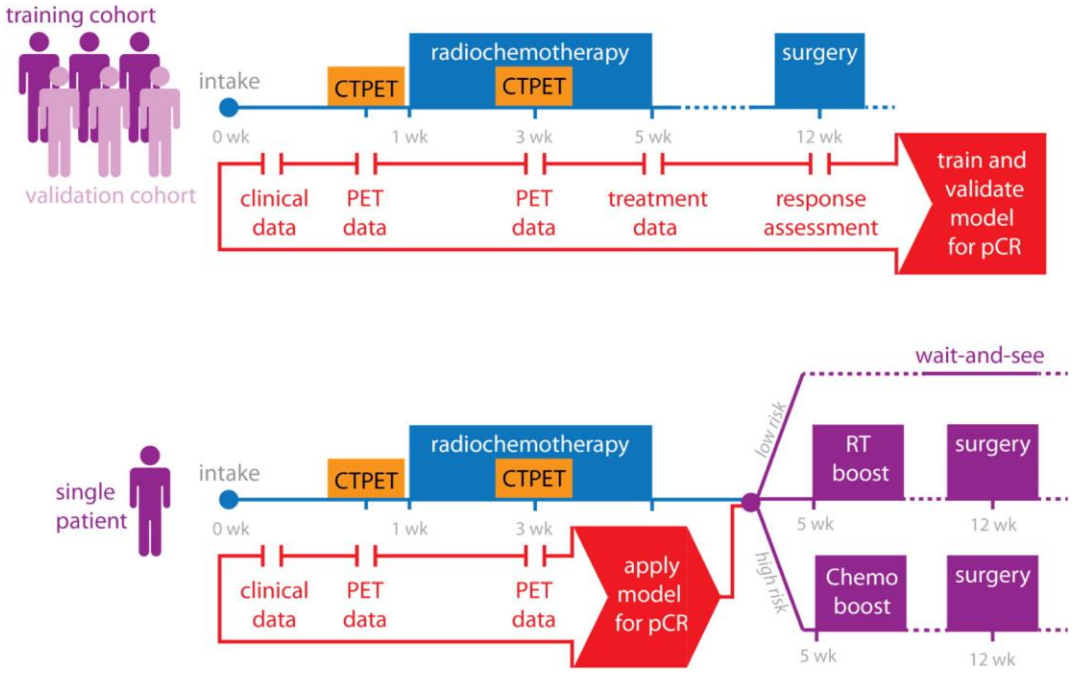
journal homepage: www.thegreenjournal.com

PET/CT in rectal cancer radiotherapy

Nomogram predicting response after chemoradiotherapy in rectal cancer using sequential PETCT imaging: A multicentric prospective study with external validation

Ruud G.P.M. van Stiphout [a,*], Vincenzo Valentini [b], Jeroen Buijsen [a], Guido Lammering [a,c], Elisa Meldolesi [b], Johan van Soest [a], Lucia Leccisotti [d], Alessandro Giordano [d], Maria A. Gambacorta [e], Andre Dekker [a], Philippe Lambin [a]

[a] Department of Radiation Oncology (MAASTRO), Maastricht University Medical Centre, The Netherlands; [b] Radiotherapy Department, Università Cattolica S. Cuore, Rome, Italy; [c] Department of Radiotherapy, MediClin Robert Janker Klinik, Bonn, Germany; [d] Department of Nuclear Medicine, Università Cattolica S. Cuore, Rome; and [e] Bioimmagini e Scienze Radiologiche, Università Cattolica S. Cuore, Rome, Italy



https://doi.org/10.1016/j.radonc.2014.11.002

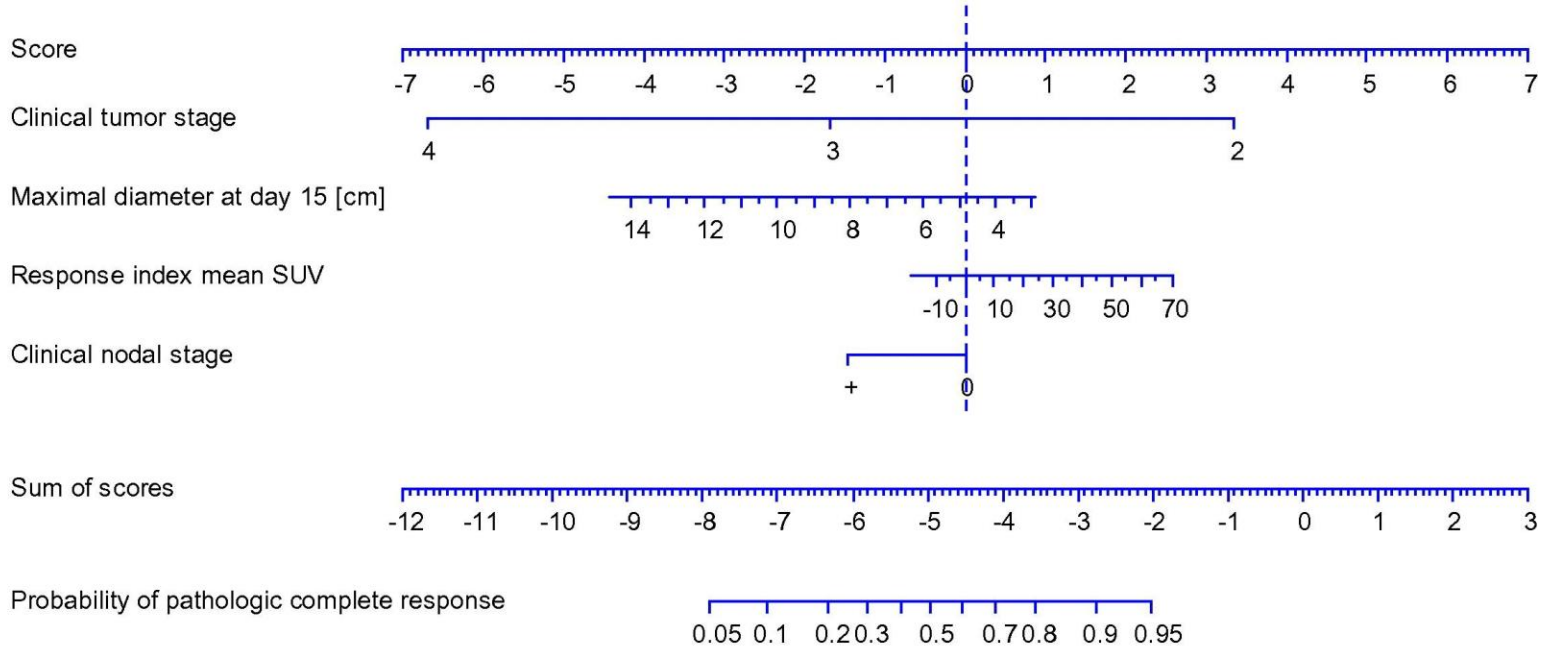
Voorspellen van de kans op CR

		Maastricht		Rome	
		N	[%]	*N*	[%]
Clinical	Sex				
	Female	29	[25.9]	28	[35.9]
	Male	83	[74.1]	50	[64.1]
	Age (years)				
	Median	65.0		66.3	
	Range	44.0–81.1		27.0–82.7	
	Clinical tumour stage				
	2	17	[15.2]	5	[6.4]
	3	86	[76.8]	49	[62.8]
	4	9	[8.0]	24	[30.8]
	Clinical nodal stage				
	0	15	[13.4]	4	[5.1]
	+	97	[86.6]	74	[94.9]
PET imaging	Time between PET scans (days)				
	Mean	21.9		28.5	
	Standard deviation	±2.5		±10.5	
	Time 1st PET injection to acquisition (minutes)				
	Mean	82.6		80.2	
	Standard deviation	±18.1		±21.3	
	Time 2nd PET injection to acquisition (minutes)				
	Mean	69.2		81.9	
	Standard deviation	±15.2		±23.0	
Treatment	Total radiotherapy dose (Gy)				
	<50.4	5	[4.5]	2	[2.6]
	50.4	107	[95.5]	15	[19.2]
	55.0	0	[0.0]	61	[78.2]
	Time last RT fraction to surgery (days)				
	Mean	73.6		72.9	
	Standard deviation	±18.8		±13.2	
Outcome	Pathologic complete response				
	Yes	24	[21.4]	18	[23.1]
	No	88	[78.6]	60	[76.9]

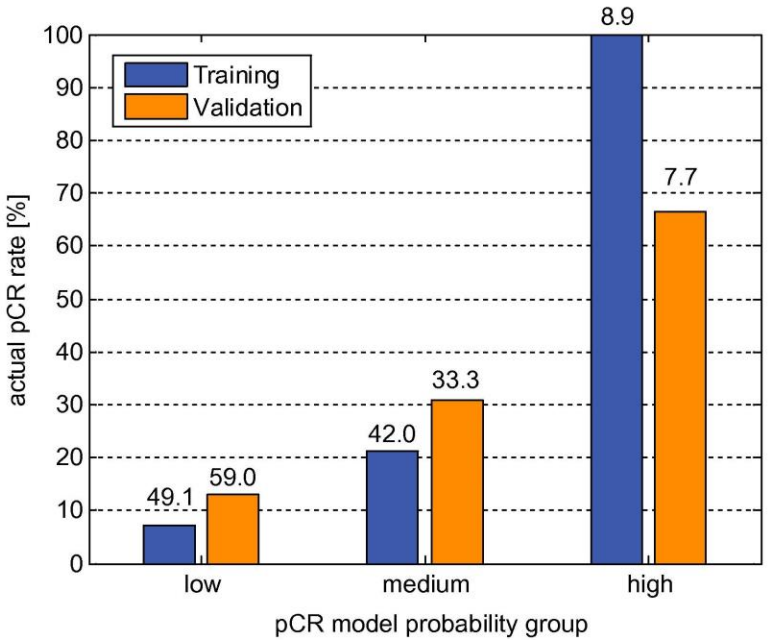
https://doi.org/10.1016/j.radonc.2014.11.002

Voorspellen van de kans op CR

A



B



The performance of the nomogram measured by AUC of 0.78 (95% CI: 0.65–0.89) for the training dataset and 0.70 (95% CI: 0.55–0.84) for the validation dataset

low: $p \leqslant 12.8\%$
medium: $12.8\% < p < 53\%$
high: $p \geqslant 53\%$.

This model may assist in treatment decisions during CRT to select complete responders for a wait-and-see policy, good responders for extra RT boost and bad responders for additional chemotherapy

https://doi.org/10.1016/j.radonc.2014.11.002

Validatie ….

Prospective validation of pathologic complete response models in rectal cancer: Transferability and reproducibility

Johan van Soest[a)]
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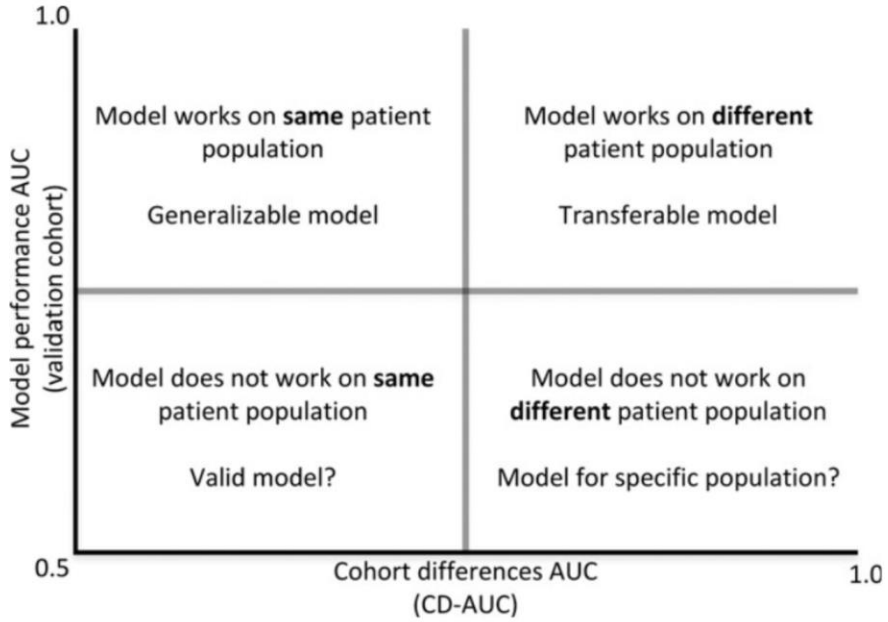
(Received 26 October 2016; revised 10 February 2017; accepted for publication 3 April 2017; published 8 August 2017)



Model	AUC training (SD)	Validation (SD)
Clinical	0.62 (0.03)	0.70 (0.06)
PET pre	0.74 (0.06)	0.66 (0.07)
PET post	0.86 (0.04)	0.58 (0.10)

https://doi.org/10.1002/mp.12423

Clinical Data Science

Federated Learning nCR

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Received: 10 November 2024 | Revised: 12 May 2025 | Accepted: 4 July 2025
DOI: 10.1002/mp.18034

RESEARCH ARTICLE

MEDICAL PHYSICS

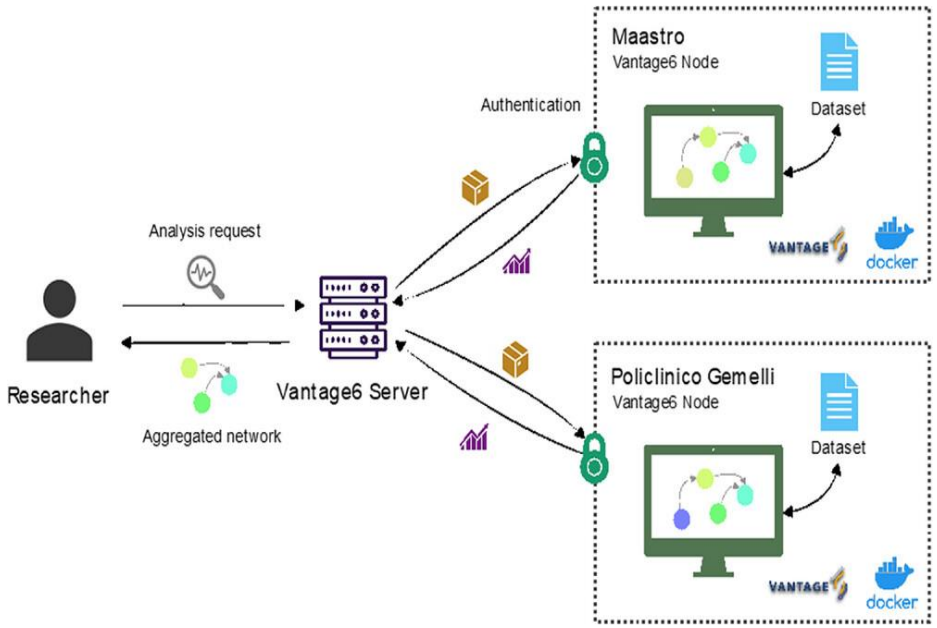
Predicting near-complete pathological response to (chemo)radiotherapy in patients with rectal cancer: A federated learning study

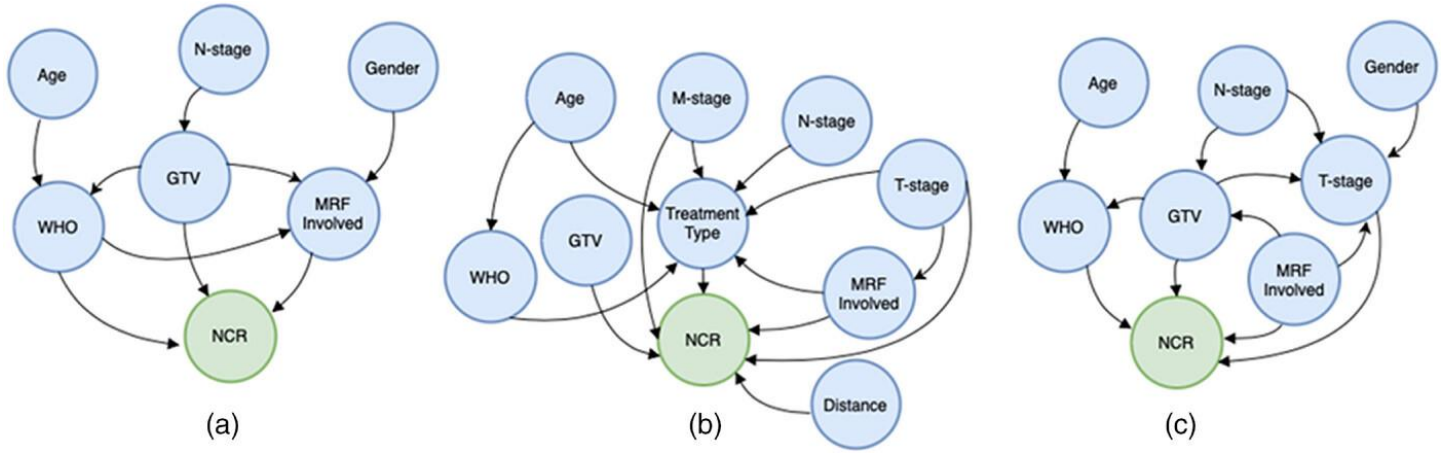
Pedro Mateus[1] | Mariachiara Savino[2] | Nikola Dino Capocchiano[2] | Maaike Berbee[1] | Maria Antonietta Gambacorta[2] | Giuditta Chiloiro[2] | Yves C. P. Willems[1] | Andrea Damiani[2] | Biche Osong[1] | Andre Dekker[1] | Inigo Bermejo[1,3]

Variable	Mean (SD)/N (%) Maastro (*N* = 439)	Policlinico Gemelli (*N* = 866)
Age	69.5 (10.4)	63.9 (11.5)
Gender		
Male	271 (61.7)	554 (64.0)
Female	168 (38.3)	312 (36.0)
WHO		
0	13 (3.0)	328 (37.9)
1	288 (65.6)	77 (8.9)
2	75 (17.1)	12 (1.4)
3	38 (8.7)	4 (0.5)
4	2 (0.5)	0 (0.0)
Missing	23 (5.2)	445 (51.4)
T		
T1	8 (1.8)	
T2	84 (19.1)	71 (8.2)
T3	283 (64.5)	611 (70.5)
T4	47 (10.7)	175 (20.2)
Tx	17 (3.9)	0 (0.0)
Missing		9 (1.0)
N		
N0	65 (14.8)	123 (14.2)
N1	142 (32.3)	394 (45.5)
N2	204 (46.5)	338 (39.0)
N3	1 (0.2)	0 (0.0)
Nx	27 (6.2)	0 (0.0)
Missing		11 (1.3)
M		
M0	345 (78.6)	851 (98.3)
M1	40 (9.1)	0 (0.0)
Mx	54 (12.3)	3 (0.3)
Missing		12 (1.4)
Distance (mm)	78.1 (39.2)	70.3 (28.9)
Missing	59 (13.4)	68 (7.8)
GTV (cm^3)	72.8 (86.2)[a]	45.6 (70.1)
Missing	6 (1.4)	710 (81.9)
MRF involved		
Yes	146 (33.3)	23 (2.6)
No	181 (41.2)	673 (77.7)
Missing	112 (25.5)	170 (19.6)
Treatment type		
Long	83 (18.9)	807 (93.2)
Short	356 (81.1)	59 (6.8)
Near complete response		
Yes	33 (7.5)	44 (5.1)
No	136 (31.0)	426 (49.2)
Missing	270 (61.5)	396 (45.7)

https://doi.org/10.1002/mp.18034

Federated Learning nCR





(a) Bayesian network structure learnt using the complete dataset from the two clinics.
(b) Bayesian network elicited from a clinical expert.
(c) Expert-elicited Bayesian network structure fine-tuned using data.

	Algorithm 2
	Cross-validation
a) Federated learning	0.77 [0.72, 0.82]
b) Trained in Maastro	0.48 [0.35, 0.61]
b) Trained in Gemelli	0.68 [0.61, 0.75]
c) Expert structure	0.68 [0.61, 0.74]
d) Expert structure + data	0.72 [0.66, 0.78]

https://doi.org/10.1002/mp.18034

Clinical Data Science

Model gebaseerde indicatie – Ook voor boost?

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Maastricht UMC+

The Dutch Initiative for the Model-Based Selection of Patients for Proton Therapy – A Federated Learning IT Infrastructure

P. Kalendralis,[1] M. Sloep,[1] J. Snel,[1,2] N. Moni George,[1] J.A. Langendijk,[3] M. Veening,[3] A. Dekker,[1,2] J. van Soest,[1,2] and R. Fijten[1]; [1]*Department of*

PROTRAIT+
IT INFRASTRUCTURE FOR RADIOTHERAPY

KWF
Dutch Cancer Society

Conclusies

- Het is mogelijk om nCR te voorspellen met een AUC ~0.80 met redelijk simpele modellen.
- Dosis op het rectum is typisch geen factor in het model (en dat is ook logisch…).
- Causaliteit van een boost voor nCR is niet vastgesteld.
- RCT met model geïndiceerde indicatie? Primaire uitkomst CR?

Clinical Data Science

Dit doe je niet alleen

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