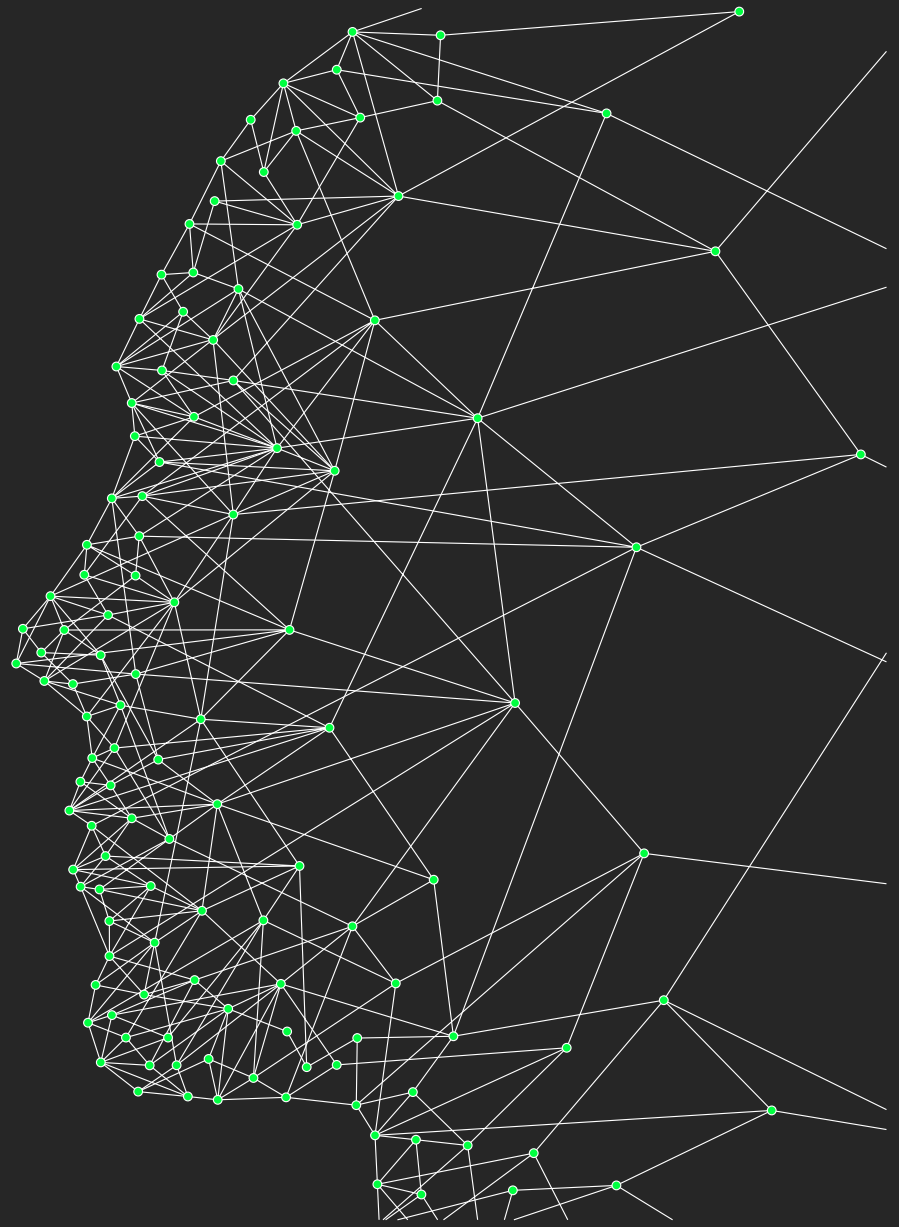
AIM

A picture is worth a thousand data points: AI imaging for cancer care



Benjamin H. Kann, MD

Assistant Professor, Radiation Oncology

Harvard Medical School | Dana-Farber Cancer Institute | Brigham and Women's Hospital | Boston Children's Hospital

Artificial Intelligence in Medicine (AIM) Program

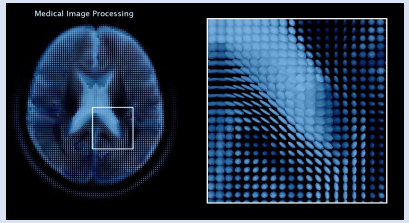
BWH BRIGHAM AND WOMEN'S HOSPITAL | Mass General Brigham | HARVARD MEDICAL SCHOOL

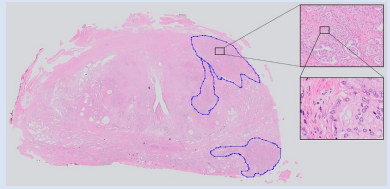
Disclosures

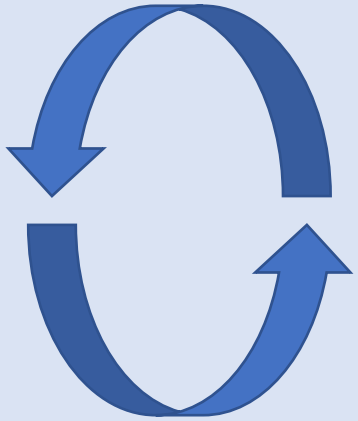
Funding:

- NIH/NIDCR K08 Mentored Clinical Scientist Research Career Development Award (KDE030216A)
- RSNA Research Scholar Award
- JCRT Foundation
- ECOG-ACRIN Clinical Research Fellowship
- DFCI Brain SPORE
- Botha Chan LGG Consortium
- ViewRay Mridian / BWH Departmental Grant

The patient data ecosystem







The cancer patient data ecosystem - **datastreams**

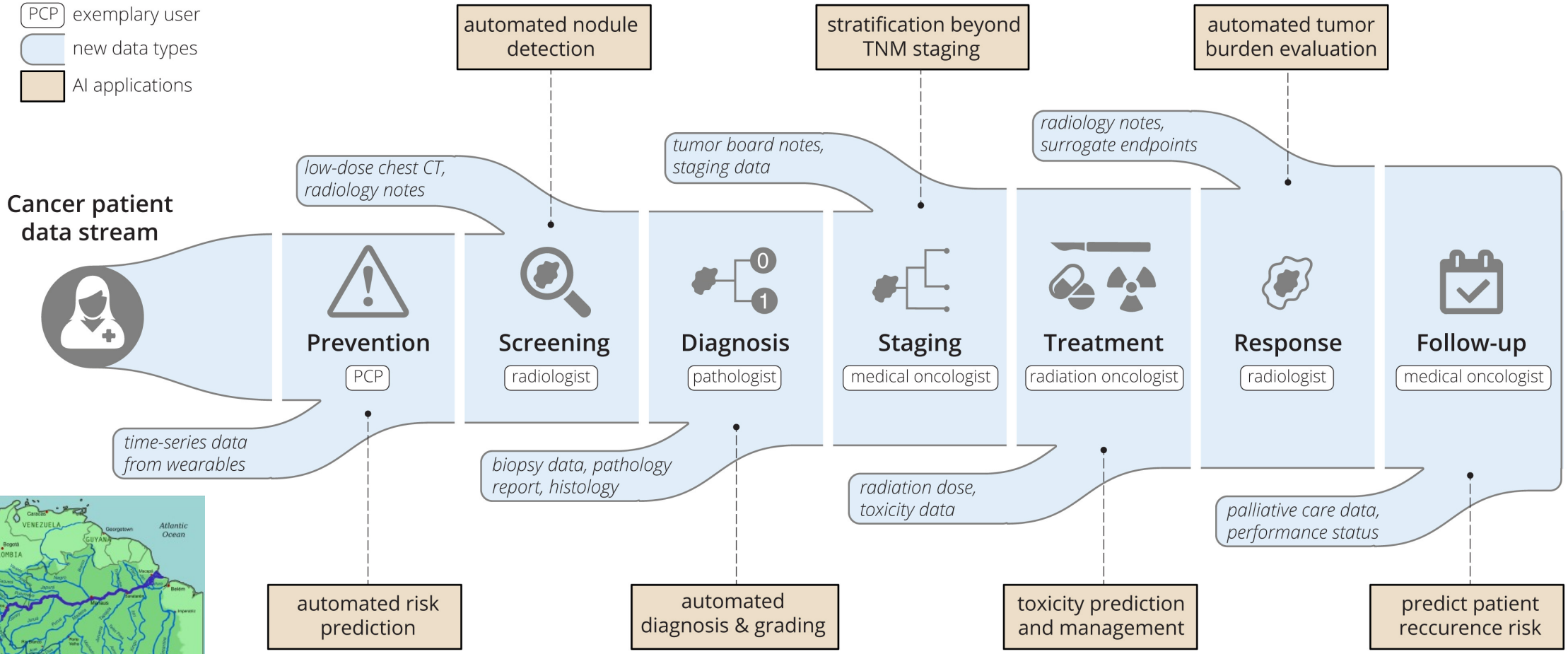
Cancer Cell

Volume 39, Issue 7, 12 July 2021, Pages 916-927

Perspective

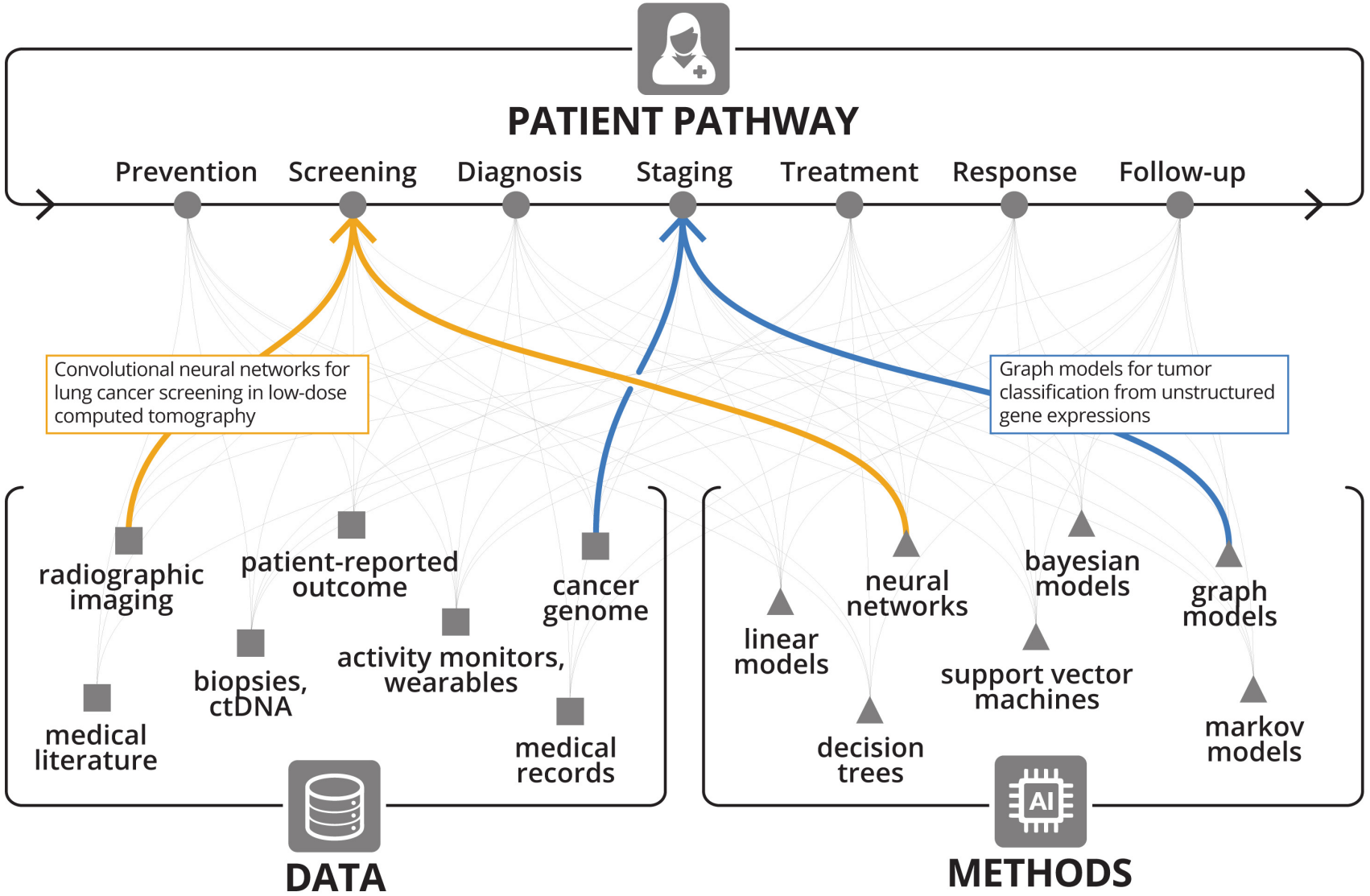
Artificial intelligence for clinical oncology

Benjamin H. Kann [1 2], Ahmed Hosny [1 2], Hugo J.W.L. Aerts [1 2 3 4]



Kann et al, Cancer Cell 2021

AI touchpoints down the cancer care pathway



Kann et al, Cancer Cell 2021

Images as data

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Robert J. Gillies, Paul E. Kinahan, Hedvig Hricak

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OPINION

Artificial intelligence in radiology

Ahmed Hosny, Chintan Parmar, John Quackenbush, Lawrence H. Schwartz & Hugo J. W. L. Aerts

Nature Reviews Cancer **18**, 500–510 (2018) | Cite this article

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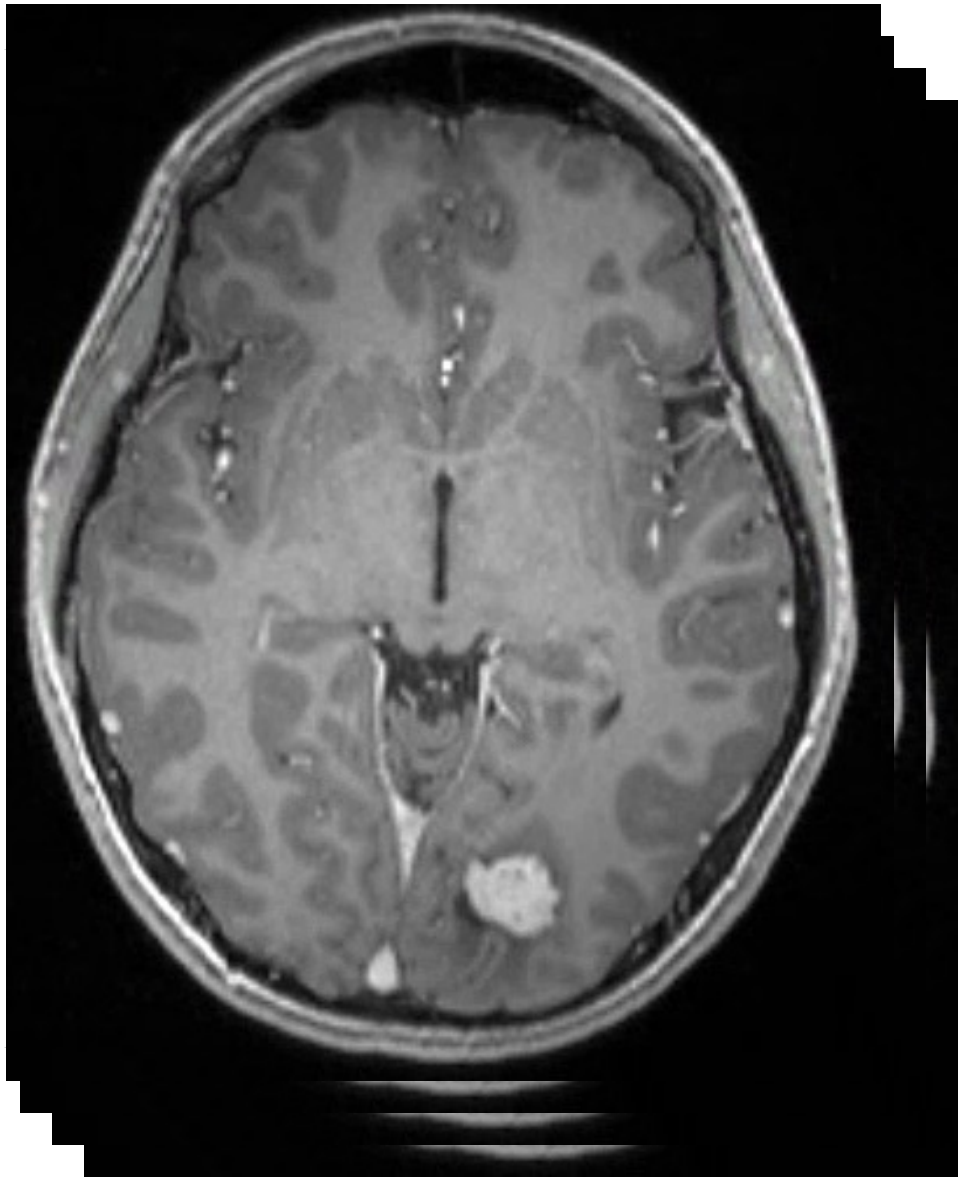
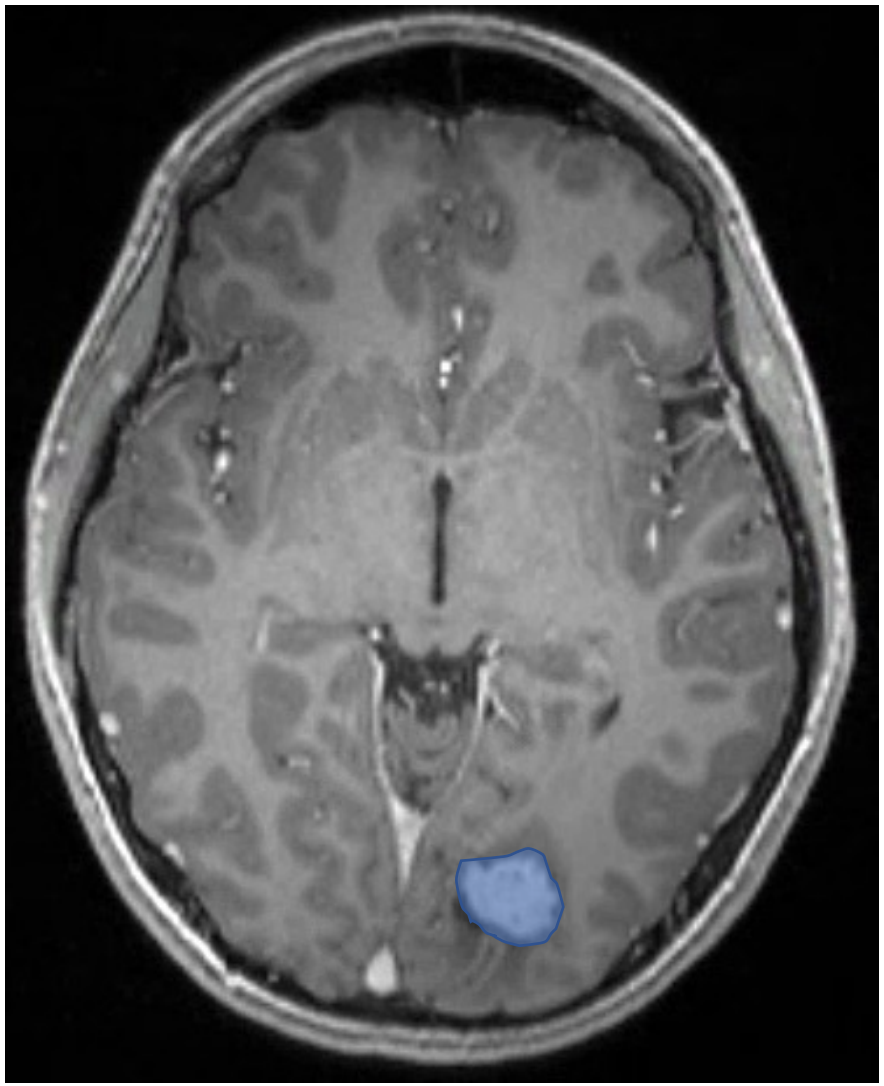
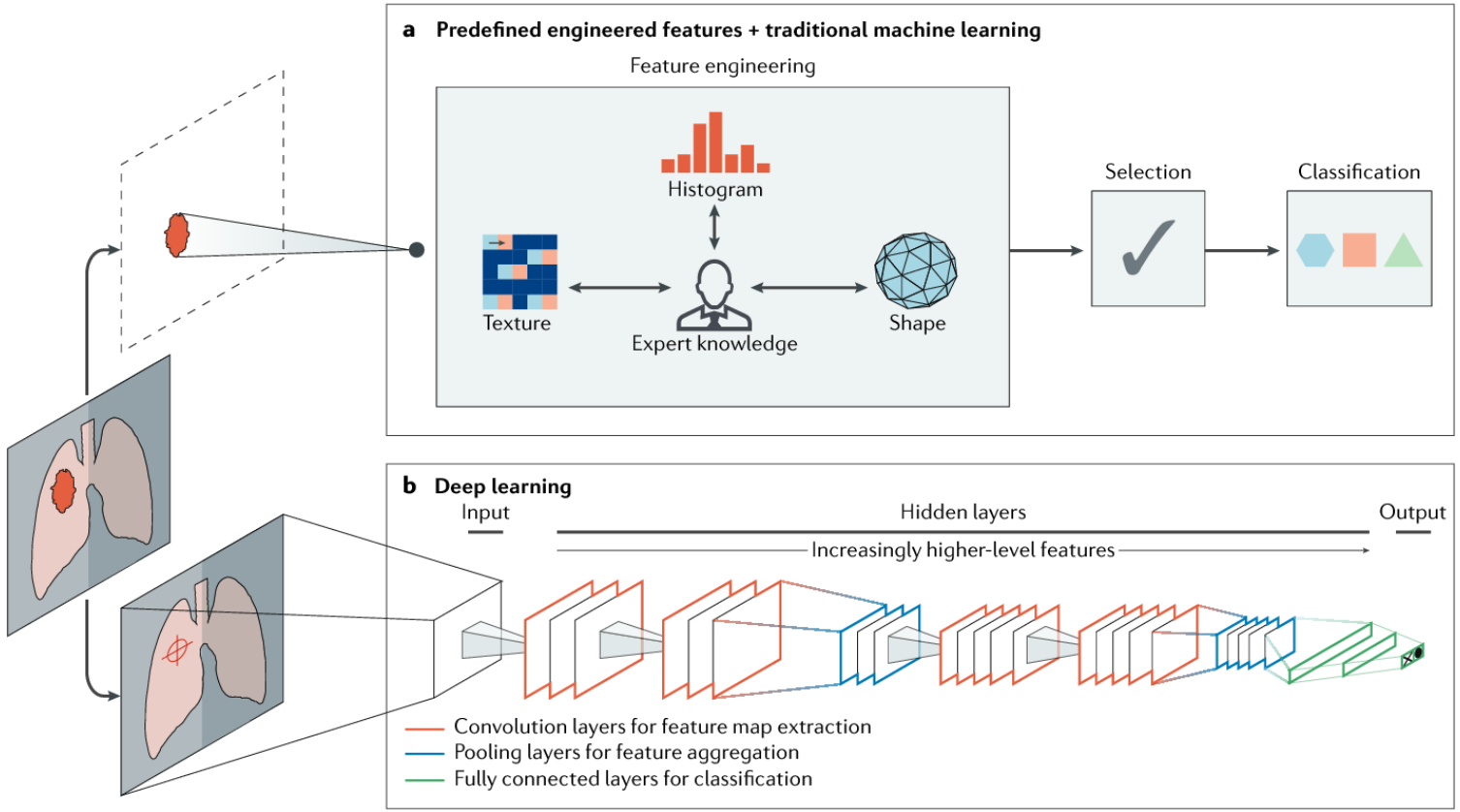


Traditional radiomics versus deep learning





Hosny et al, Nat Rev Cancer 2018

A picture is worth a thousand data points

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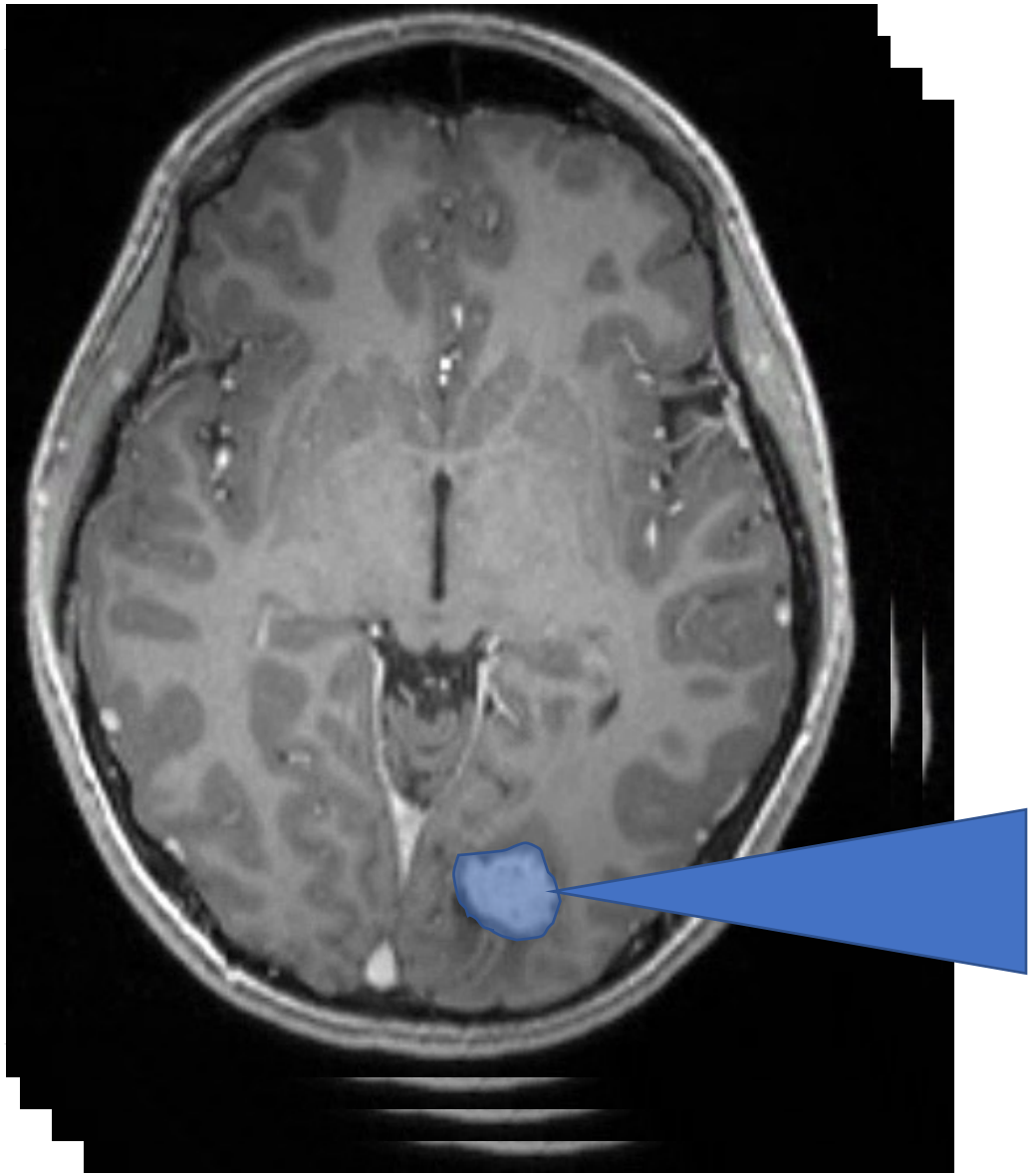

Tumor

- Segmentation
- Volumetrics
- Pathologic features
- Molecular subtyping
- Chemoradiosensitivity
- Response prediction

A picture is worth a thousand data points

Patient (Normal tissues)
- Neurocognition
- Development

- Body composition
- Frailty, cachexia, sarcopenia

- Endocrinopathies

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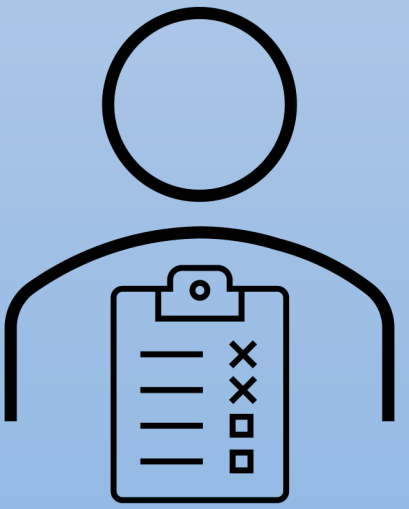
AI-generated Patient Risk Profile



Tumor
- Segmentation
- Volumetrics
- Pathologic features
- Molecular subtyping
- Chemoradiosensitivity
- Response prediction

Outline

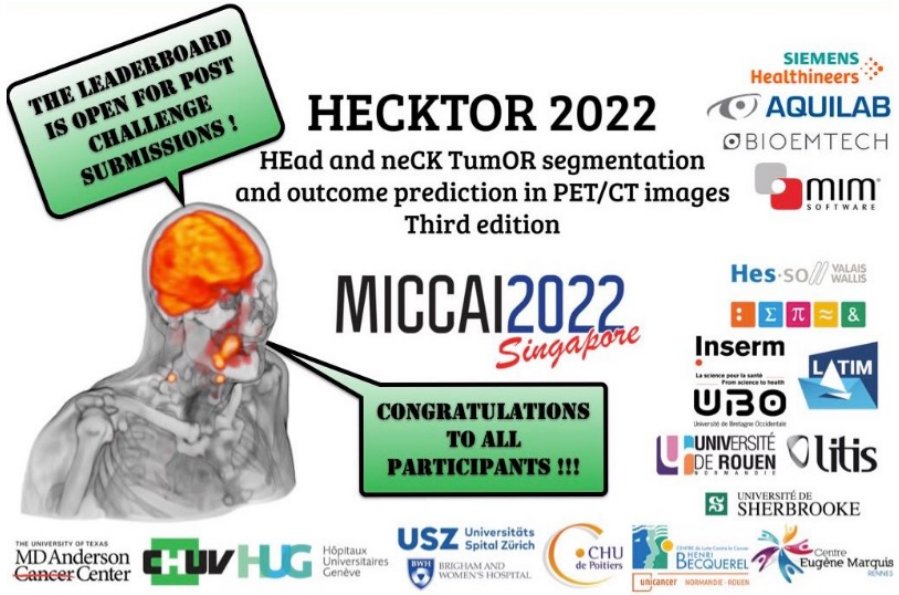
1) AI and the patient data ecosystem

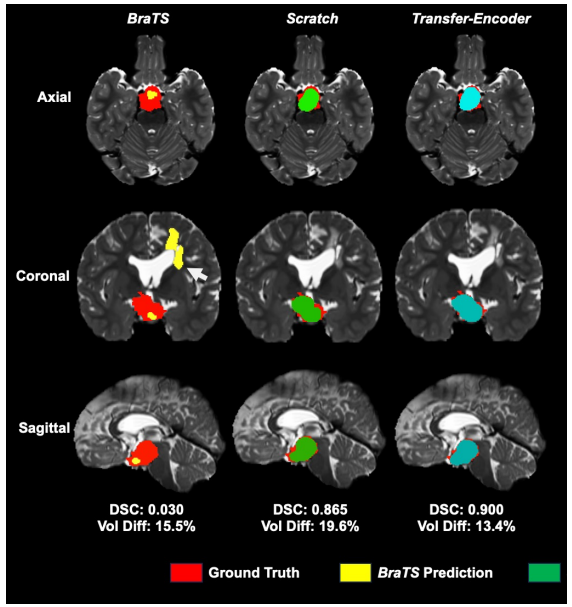
2) Images as data

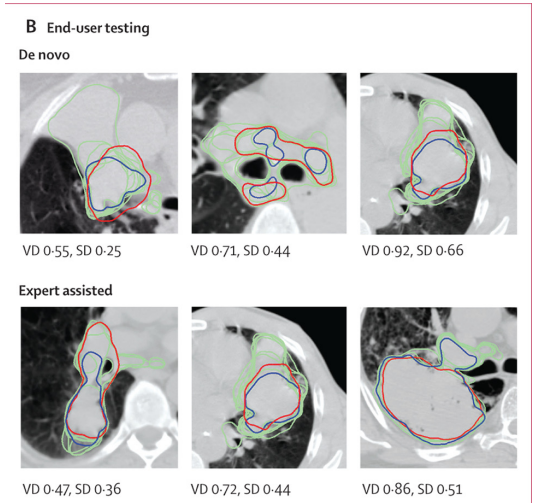
3) AI imaging applications for cancer

Achievement: Narrow-task computer vision

Tumor and organ segmentation







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4 Sept. 2022	0.78632
2 Sept. 2022	0.78133
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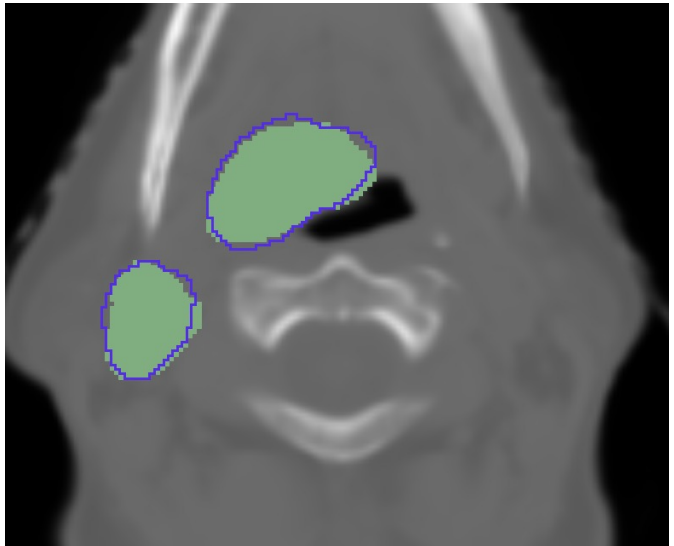
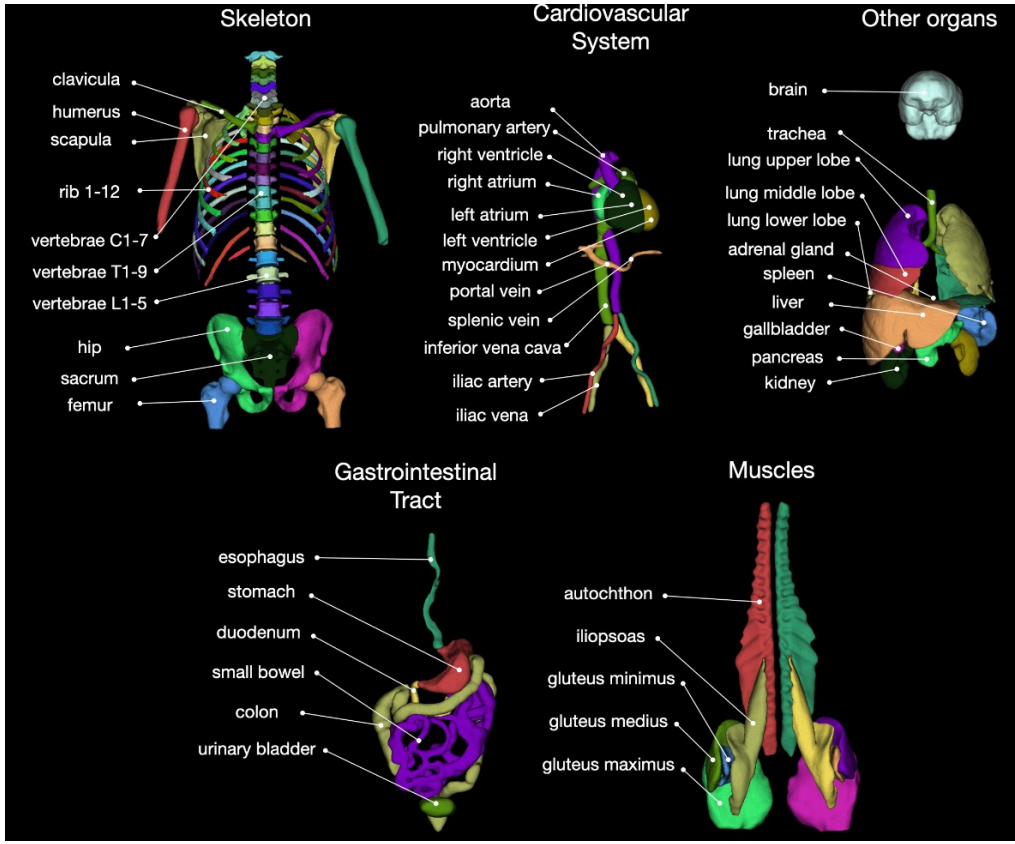
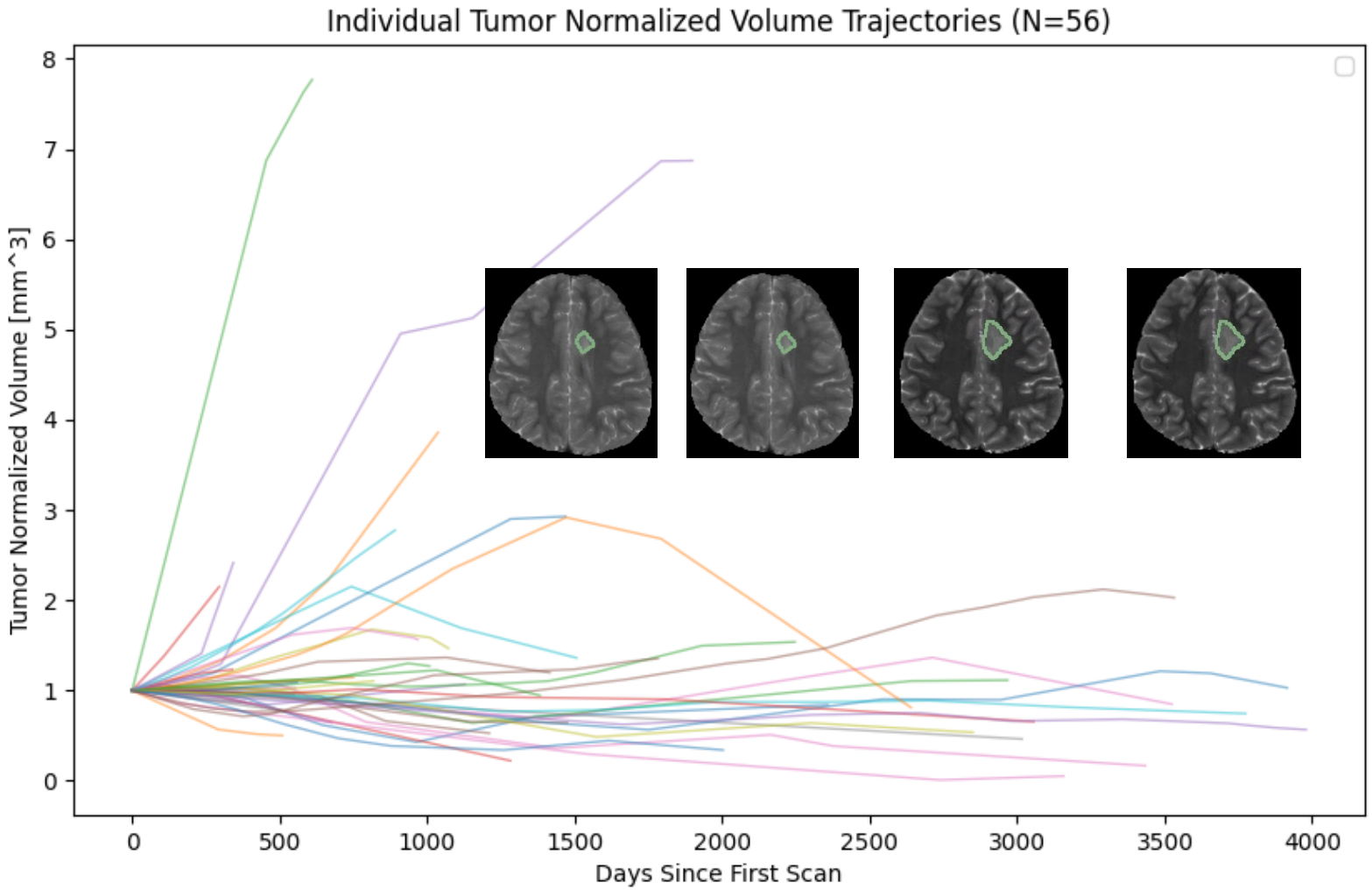




A new era: rapid volumetric assessment and tracking with AI – case study in pLGG



BCH/DFCI Surveillance Cohort (n=56)

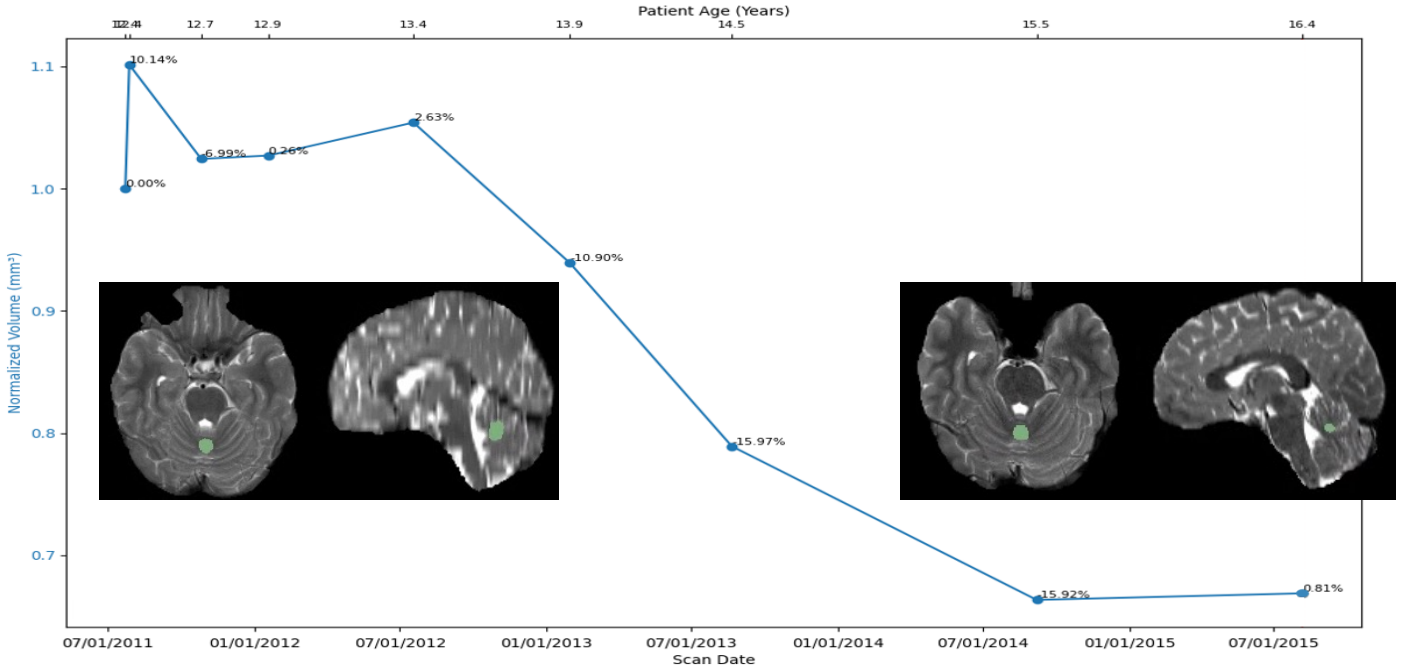
Median follow-up: 9.1 yrs
(range: 0.4 – 29.7 yrs)

Juan Carlos Climento Pardo

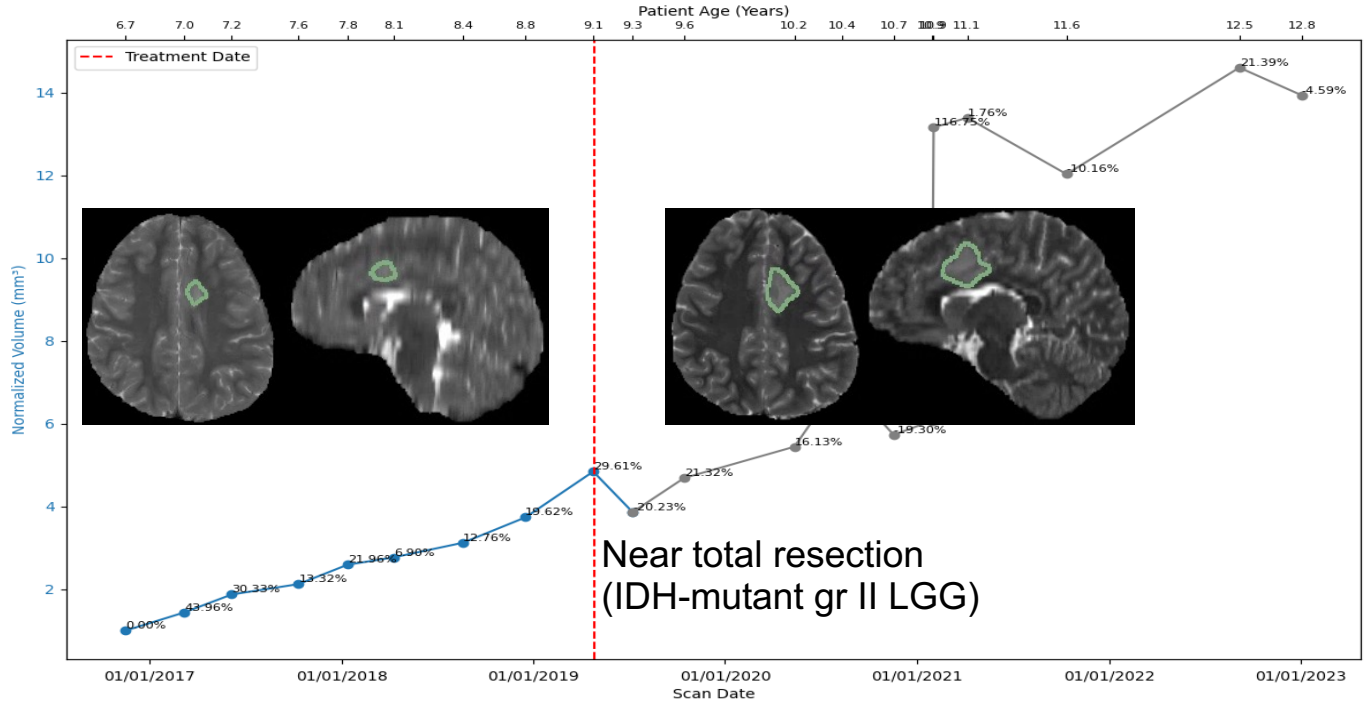
In preparation, do not post

Phenotypes:
Regressors and Progressors

12 yo boy incidentally found, amidst headaches post-sports trauma



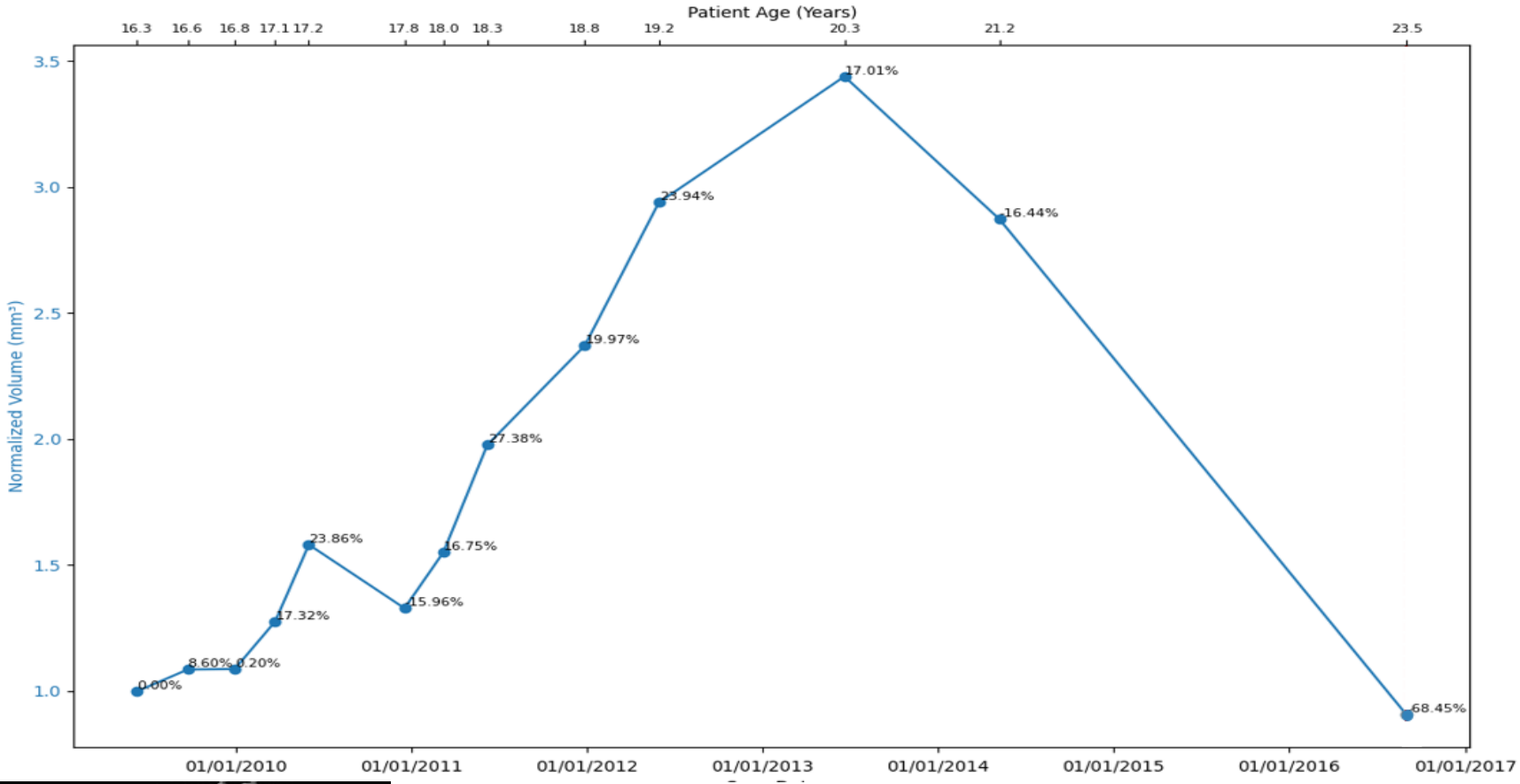
9 yo girl presents with seizures

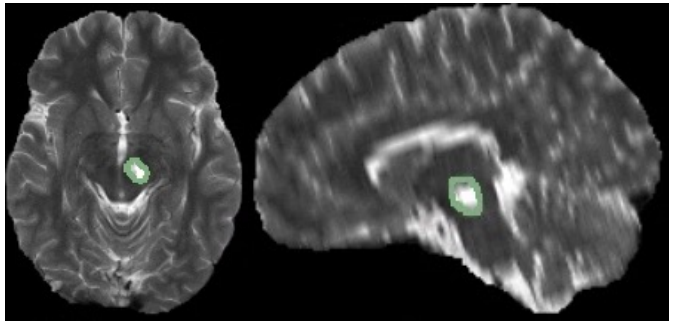


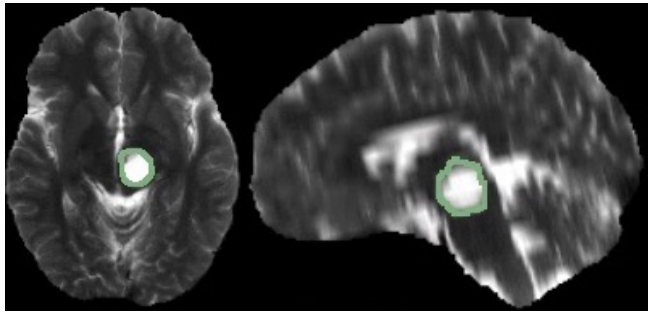
Near total resection (IDH-mutant gr II LGG)

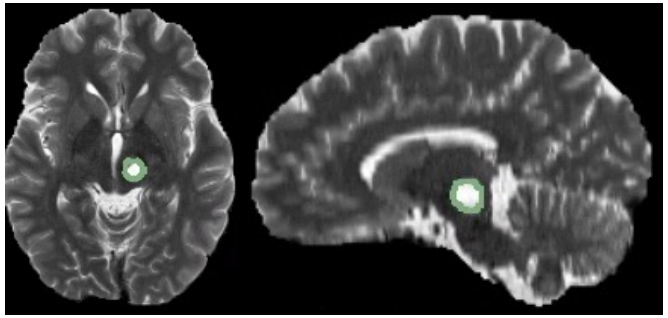
Phenotype: Waxing and Waning

16yo M, presents after bike riding accident









Temporalis muscle (TM) segmentation: cross-sectional area and thickness

Anna Zapaishchykova

Cancer- and treatment-related **cachexia/sarcopenia** are major problems in pediatric CNS malignancies

TM thickness is a validated prognosticator and surrogate for cachexia/sarcopenia in adult malignancies (GBM, CNS lymphoma, head/neck)

There are currently no good predictive markers for cachexia in pediatric cancer patients

TM analysis may be helpful in stratifying risk and driving early interventions

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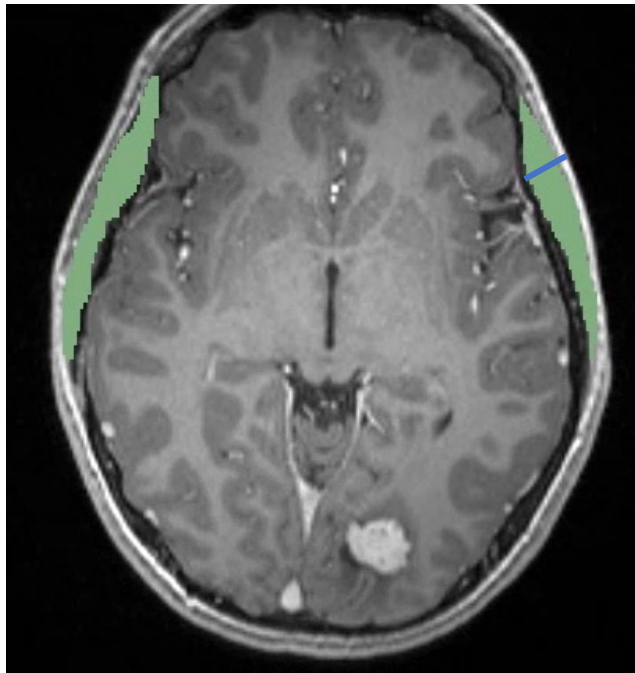
Article | Open access | Published: 09 November 2023

Automated temporalis muscle quantification and growth charts for children through adulthood

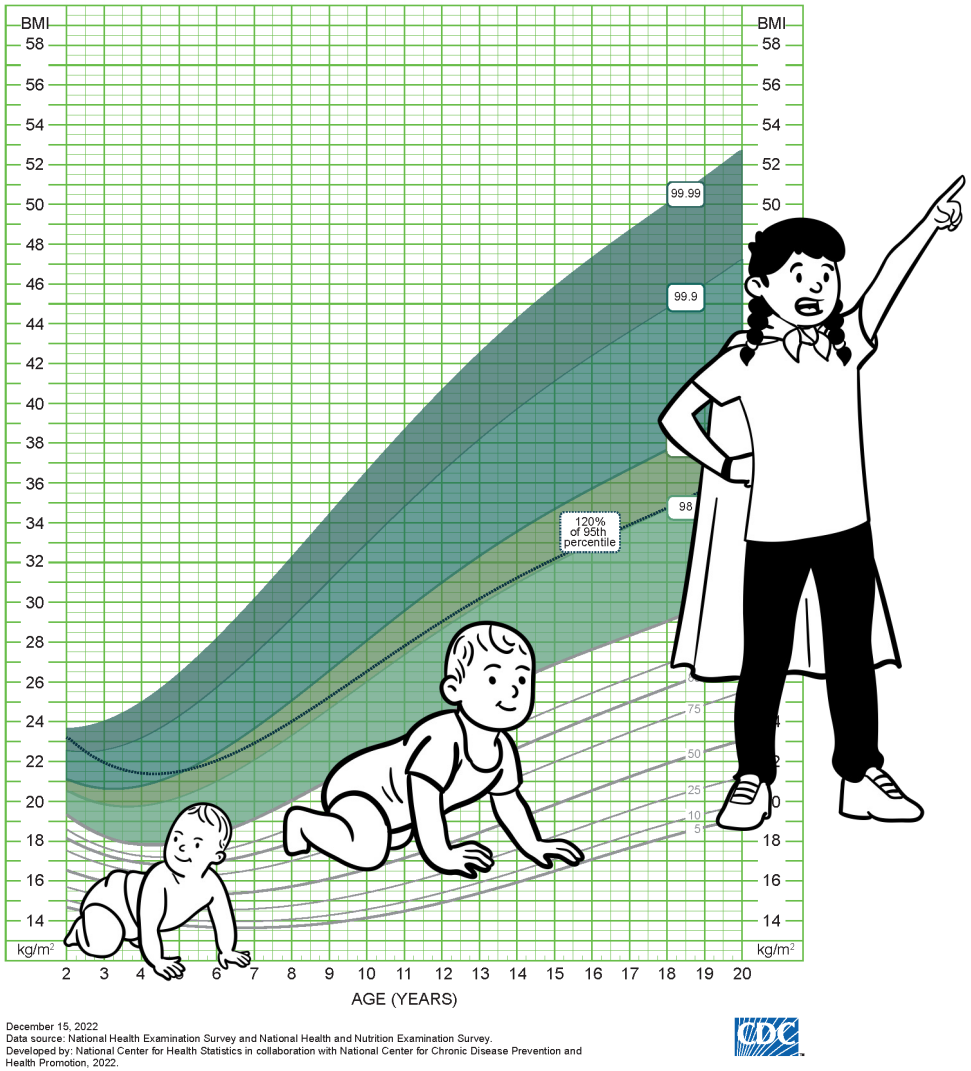
Anna Zapaishchykova, Kevin X. Liu, Anurag Saraf, Zezhong Ye, Paul J. Catalano, Viviana Benitez, Yashwanth Ravipati, Arnav Jain, Julia Huang, Hasaan Hayat, Jirapat Likitlersuang, Sridhar Vajapeyam, Rishi B. Chopra, Ariana M. Familiar, Ali Nabavidazeh, Raymond H. Mak, Adam C. Resnick, Sabine Mueller, Tabitha M. Cooney, Daphne A. Haas-Kogan, Tina Y. Poussaint, Hugo J.W.L. Aerts & Benjamin H. Kann

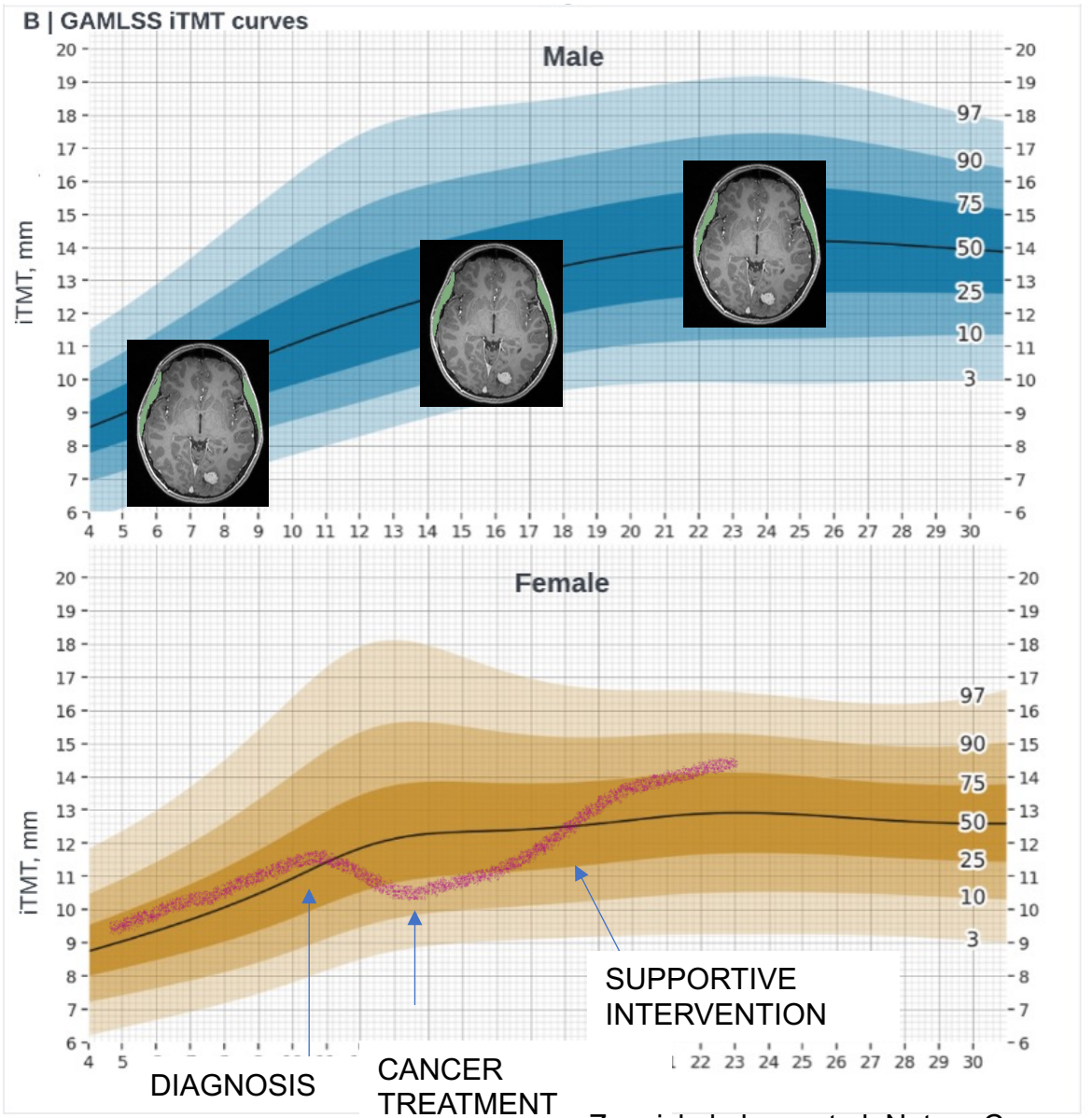


Furtner J, Nenning KH, Roetzer T, Gesperger J, Seebrecht L, Weber M, Grams A, Leber SL, Marhold F, Sherif C, Trenkler J, Kiesel B, Widhalm G, Asenbaum U, Woitek R, Berghoff AS, Prayer D, Langs G, Preusser M, Wöhrer A. Evaluation of the Temporal Muscle Thickness as an Independent Prognostic Biomarker in Patients with Primary Central Nervous System Lymphoma. Cancers (Basel). 2021 Feb 2;13(3):566. doi: 10.3390/cancers13030566. PMID: 33540564; PMCID: PMC7867149.

Lee, B., Bae, Y.J., Jeong, WJ. *et al.* Temporalis muscle thickness as an indicator of sarcopenia predicts progression-free survival in head and neck squamous cell carcinoma. *Sci Rep* **11,** 19717 (2021). https://doi.org/10.1038/s41598-021-99201-3

Temporalis muscle **growth charts**





Zapaishchykova et al, Nature Communications, 2023

Achievement: Narrow-task computer vision
Cancer screening and risk prediction with BIG data

Sybil: A Validated Deep Learning Model to Predict Future Lung Cancer Risk From a Single Low-Dose Chest Computed Tomography

Check for updates

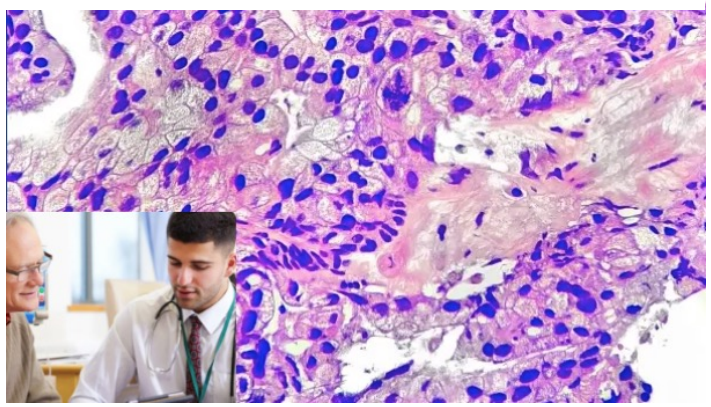
Peter G. Mikhael, BSc[1,2]; Jeremy Wohlwend, ME[1,2]; Adam Yala, PhD[1,2]; Ludvig Karstens, MSc[1,2]; Justin Xiang, ME[1,2]; Angelo K. Takigami, MD[3,4]; ...

ORIGINAL ARTICLE

Artificial Intelligence Predictive Model for Hormone Therapy Use in Prostate Cancer

Authors: Daniel E. Spratt, M.D., Siyi Tang, Ph.D., Yilun Sun, Ph.D., Huei-Chung Huang, M.A., Emmalyn Chen, Ph.D., Osama Mohamad, M.D., Ph.D., Andrew J. Armstrong, M.D., +21 for NRG Prostate Cancer AI Consortium* Author Info & Affiliations

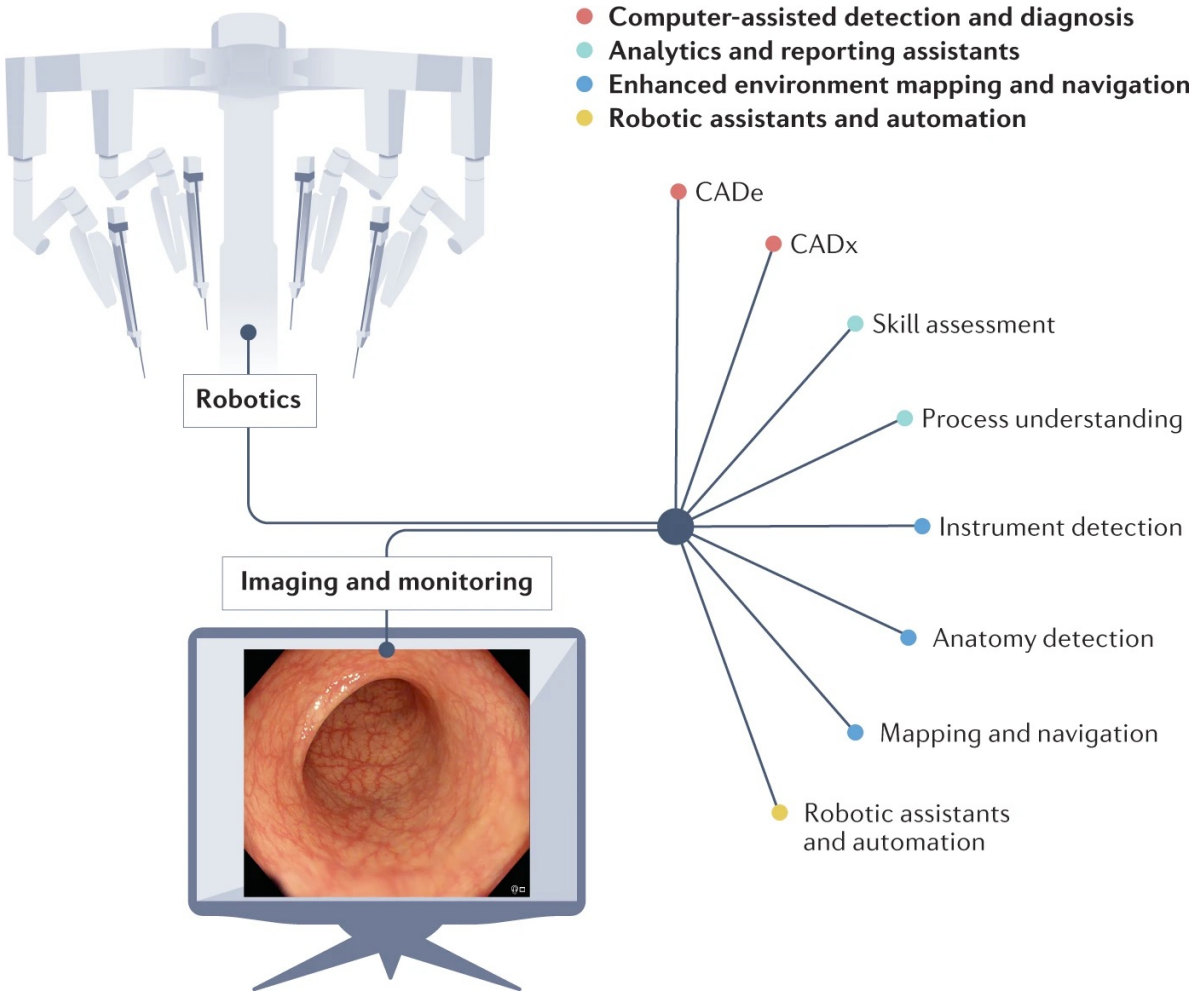
ARTERA



Achievement: Narrow-task computer vision

Cancer screening and risk prediction with BIG data

Endoscopy



Chadebecq et al, Nature Reviews, 2022

Mammography

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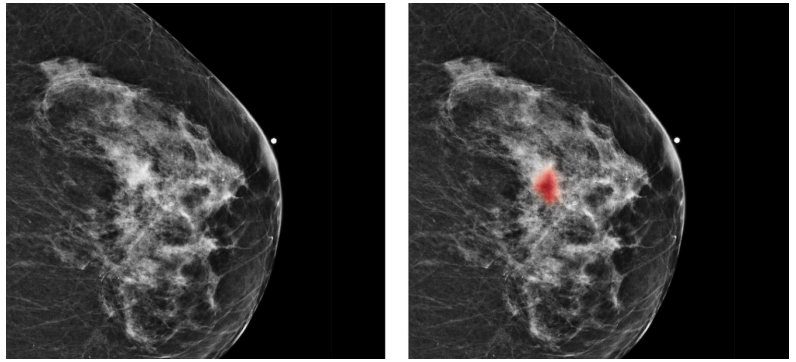
Article | Published: 01 January 2020

International evaluation of an AI system for breast cancer screening

Scott Mayer McKinney, Marcin Sieniek, Varun Godbole, Jonathan Godwin, Natasha Antropova, Hutan Ashrafian, Trevor Back, Mary Chesus, Greg S. Corrado, Ara Darzi, Mozziyar Etemadi, Florencia Garcia-Vicente, Fiona J. Gilbert, Mark Halling-Brown, Demis Hassabis, Sunny Jansen, Alan Karthikesalingam, Christopher J. Kelly, Dominic King, Joseph R. Ledsam, David Melnick, Hormuz Mostofi, Lily Peng, Joshua Jay Reicher, … Shravya Shetty + Show authors



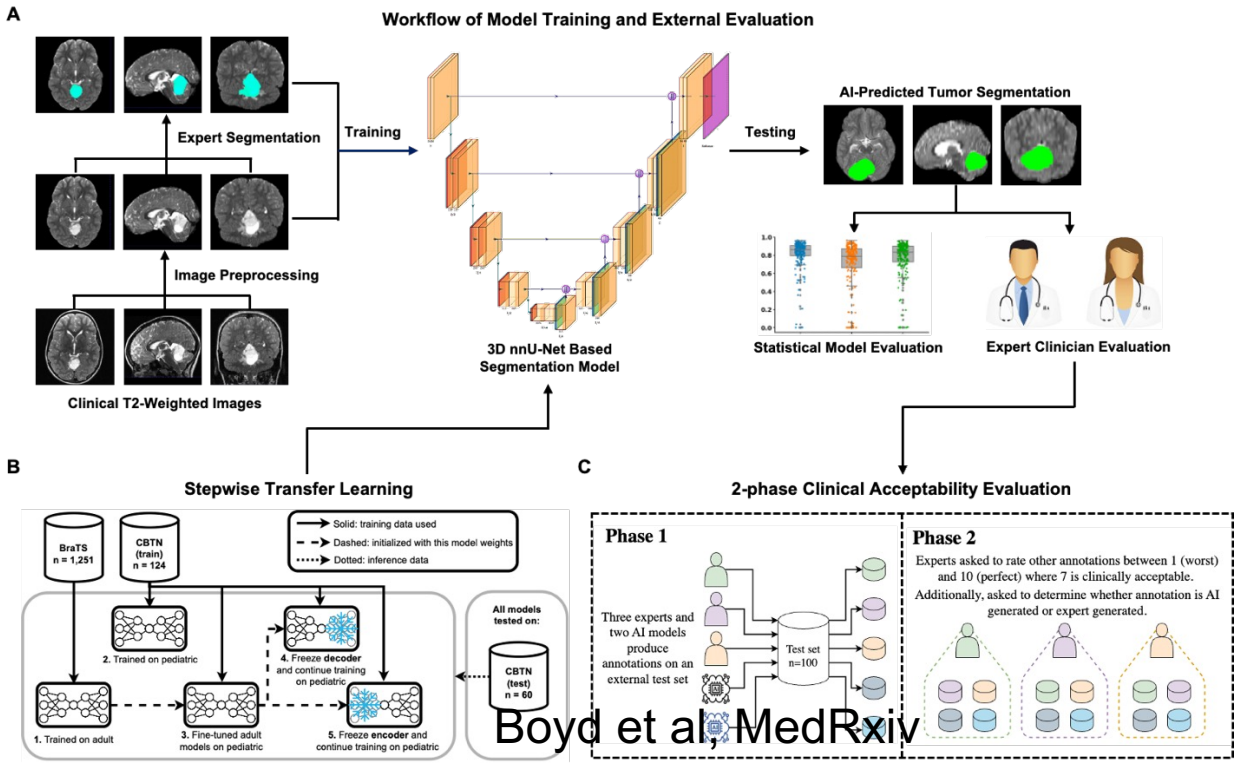
New frontier: Narrow-task computer vision with SMALL data

- Many of the most detrimental cancers are less common
- Can AI still be applied?

Expert-level pediatric brain tumor segmentation in a limited data scenario with stepwise transfer learning

Aidan Boyd, Zezhong Ye, Sanjay Prabhu, Michael C. Tjong, Yining Zha, Anna Zapaishchykova, Sridhar Vajapeyam, Hasaan Hayat, Rishi Chopra, Kevin X. Liu, Ali Nabavidazeh, Adam Resnick, Sabine Mueller, Daphne Haas-Kogan, Hugo J.W.L. Aerts, Tina Poussaint, Benjamin H. Kann

doi: https://doi.org/10.1101/2023.06.29.23292048

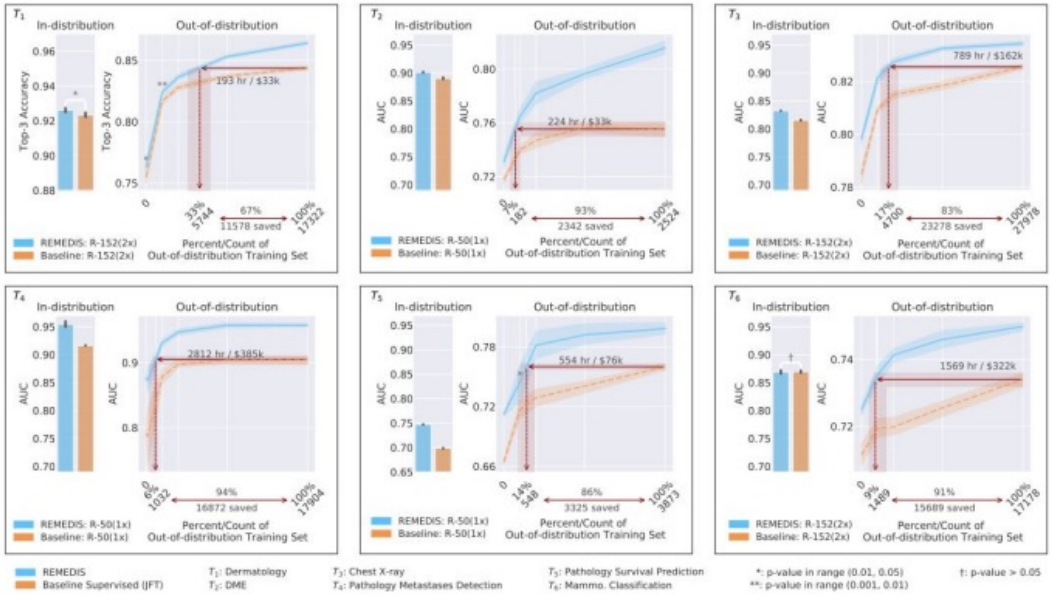


Boyd et al, MedRxiv

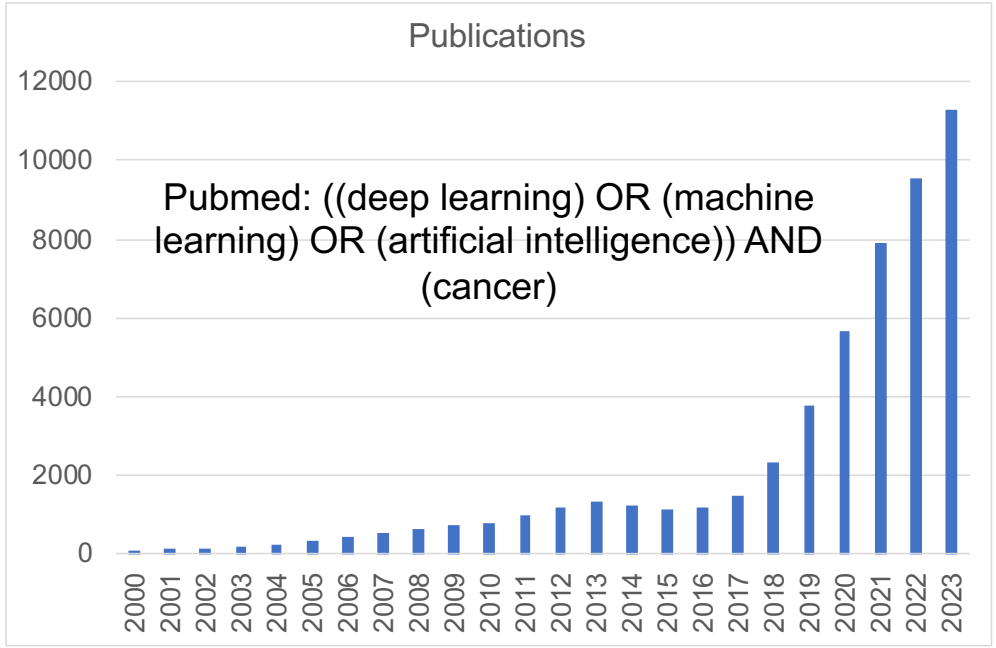
Robust and Efficient Medical Imaging with Self-Supervision

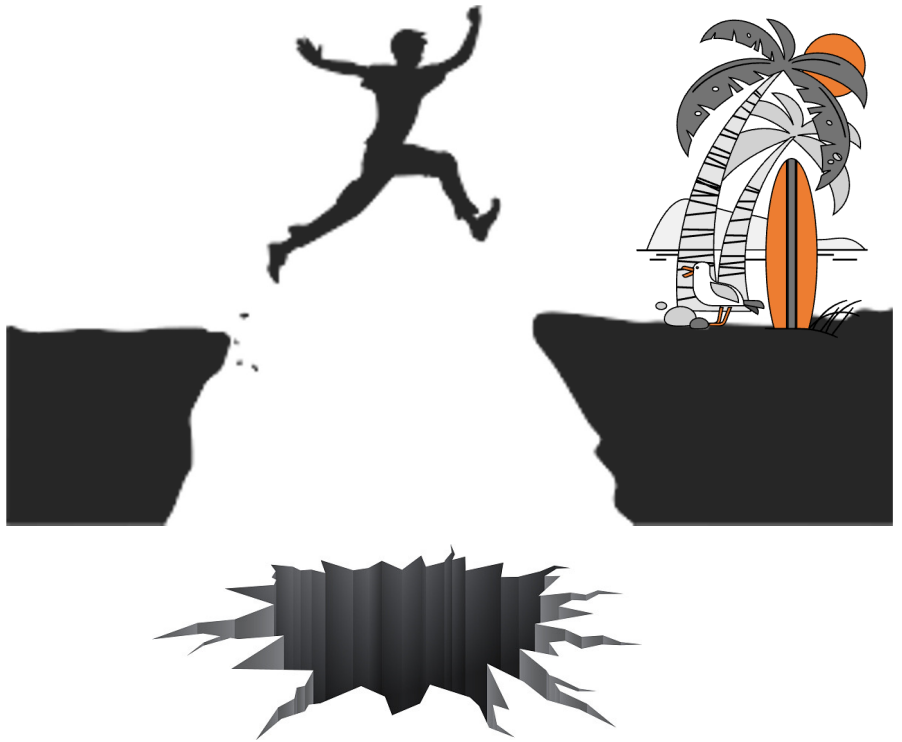
Shekoofeh Azizi*,†,1, Laura Culp*,1, Jan Freyberg*,1, Basil Mustafa1, Sebastien Baur1, Simon Kornblith1, Ting Chen1, Patricia MacWilliams1, S. Sara Mahdavi1, Ellery Wulczyn1, Boris Babenko1, Megan Wilson1, Aaron Loh1, Po-Hsuan Cameron Chen1, Yuan Liu1, Pinal Bavishi1, Scott Mayer McKinney1, Jim Winkens1, Abhijit Guha Roy1, Zach Beaver1, Fiona Ryan2, Justin Krogue1, Mozziyar Etemadi3, Umesh Telang1, Yun Liu1, Lily Peng1, Greg S. Corrado1, Dale R. Webster1, David Fleet1, Geoffrey Hinton1, Neil Houlsby†,1, Alan Karthikesalingam†,‡,1, Mohammad Norouzi†,1 and Vivek Natarajan†,‡,1

1Google Research, 2Georgia Institute of Technology, 3Northwestern University



New frontier: the AI translational gap





Randomized Clinical Trials of Machine Learning Interventions in Health Care

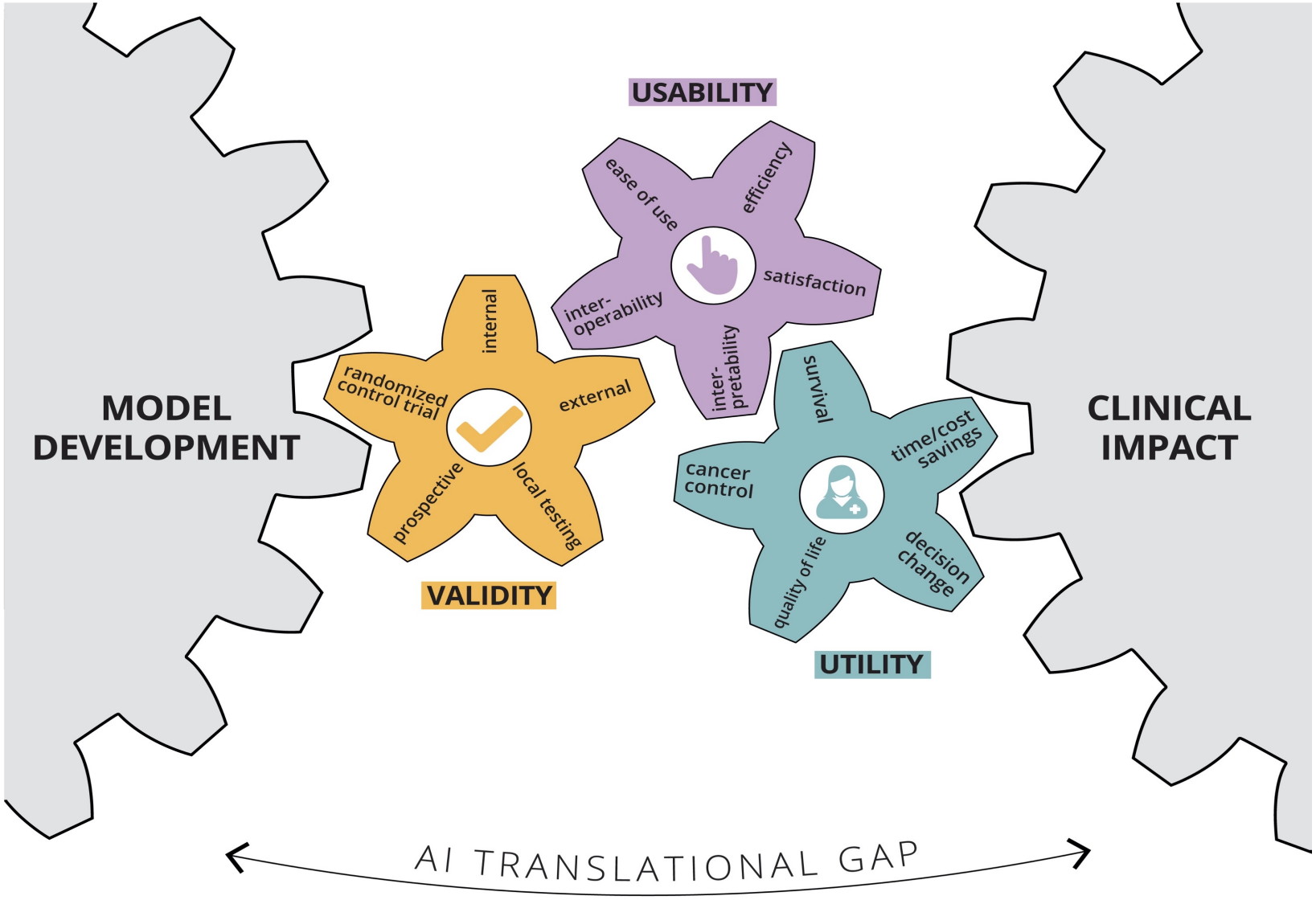
A Systematic Review

Deborah Plana, BS[1]; Dennis L. Shung, MD, PhD[2]; Alyssa A. Grimshaw, MSLIS[3]; Anurag Saraf, MD[4]; Joseph J. Y. Sung, MBBS, PhD[5]; Benjamin H. Kann, MD[6]

- **41** AI RCTs in all medicine[1]
  - 16 endoscopy-related
- **2** published AI radiographic imaging RCTs[2]

[1]Plana et al, JAMA Network Open, 2022
[2]Nagendran et al, BMJ 2020

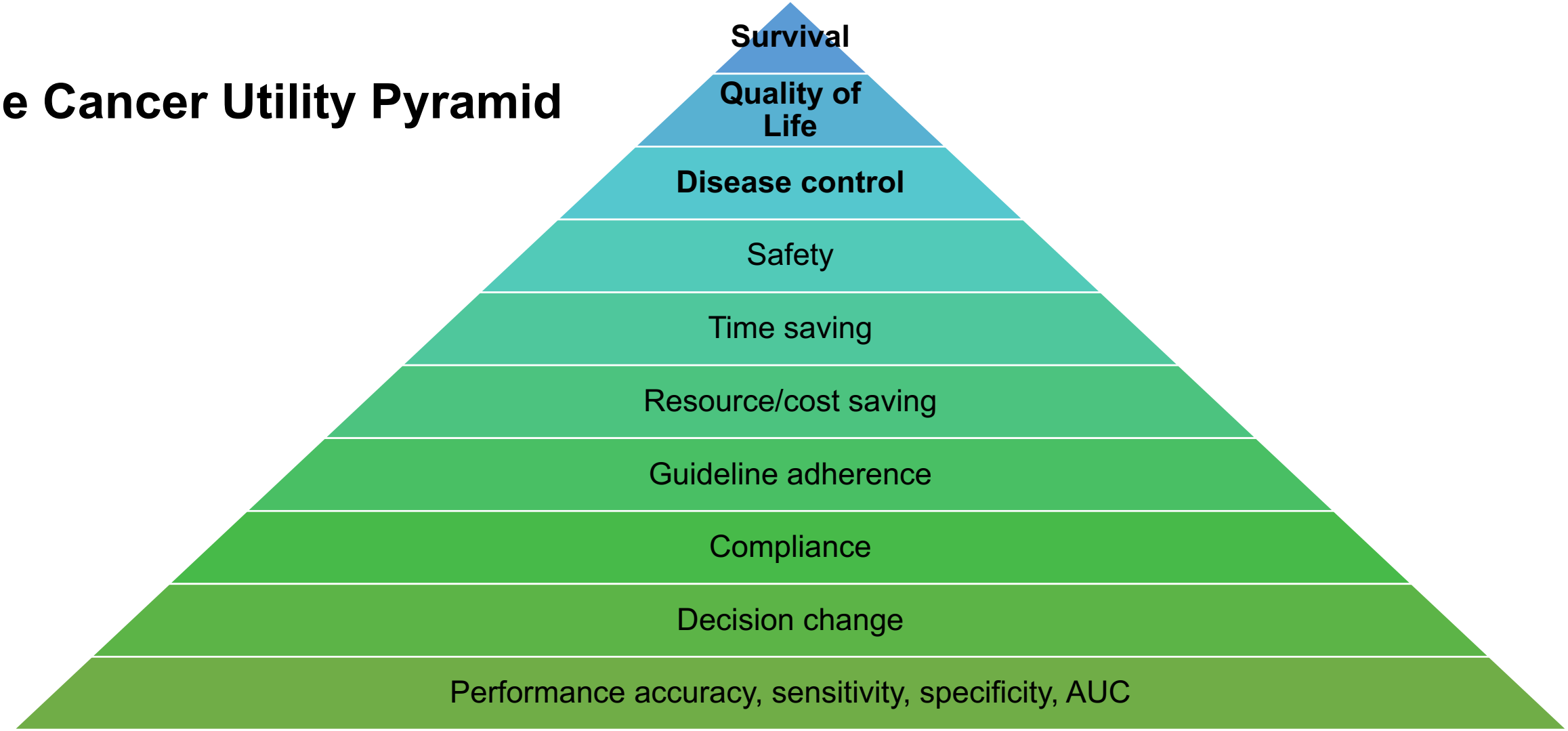
New frontier: the AI translational gap



Kann et al, Cancer Cell 2021

New frontier: the AI translational gap – clinical utility

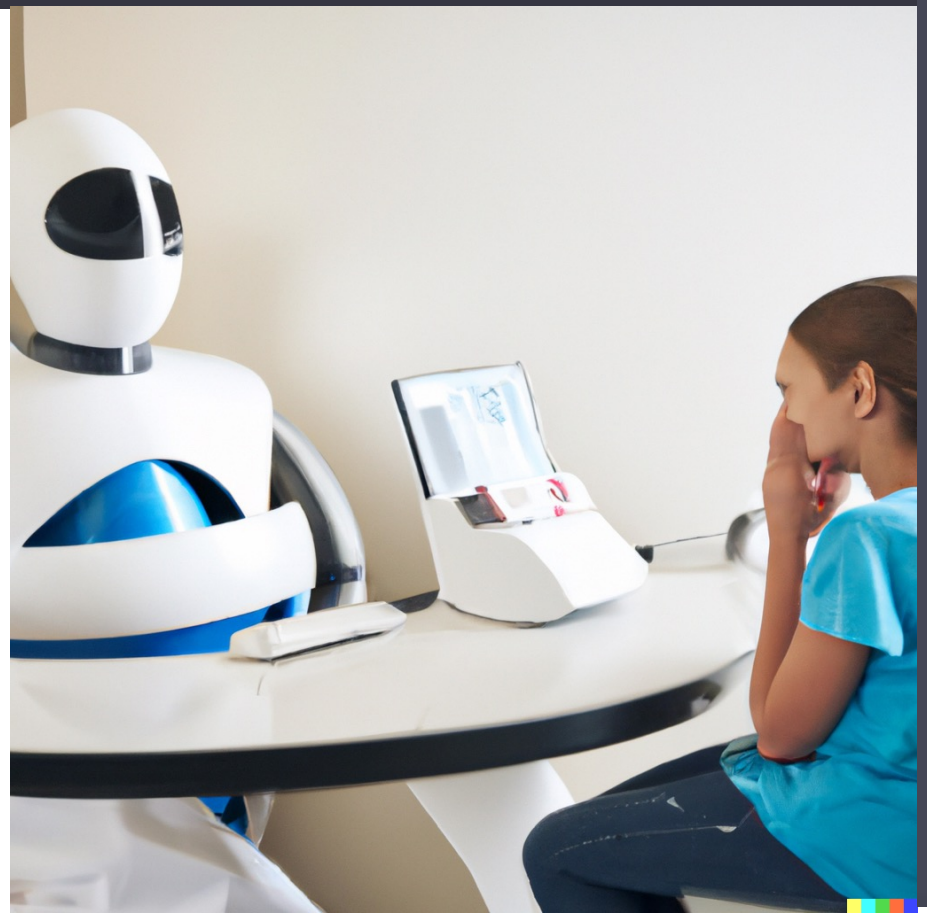
The Cancer Utility Pyramid



New frontier: LLMs and patient care

You are an oncologist. An 8 year old boy presents with seizures and headaches, and on MR imaging is found to have a 6 cm tumor in the right temporal lobe. The tumor is biopsied and found to be consistent with a low grade glioma with a BRAF fusion mutation. How you would treat this patient?

GPT, MD?



The management of a pediatric patient with a low-grade glioma with a BRAF fusion mutation typically involves a multimodal approach that includes surgery, radiation therapy, and/or chemotherapy. The specific treatment plan will depend on several factors, including the tumor size and location, the patient's age and overall health, and the extent of the tumor.

Surgery is usually the first step in treatment, with the goal of removing as much of the tumor as possible without causing significant damage to the surrounding brain tissue. In some cases, complete removal of the tumor may not be possible due to its location in the brain or the risk of damage to critical brain structures. In these situations, the neurosurgeon may perform a biopsy to confirm the diagnosis and relieve pressure on the brain caused by the tumor.

After surgery, the patient may undergo radiation therapy to help prevent the tumor from growing back. Radiation therapy is typically delivered in small doses over a period of several weeks to minimize side effects. In some cases, chemotherapy may be used instead of or in addition to radiation therapy, especially if the tumor is large or has spread to other parts of the brain.

Because the patient in this case is only 8 years old, the treatment team will need to take into account the potential long-term side effects of treatment on his developing brain. For example, radiation therapy to the brain can increase the risk of cognitive problems and secondary tumors later in life. Chemotherapy can also have significant side effects, including nausea, vomiting, and hair loss.

New frontier: LLMs and patient care

Use of Artificial Intelligence Chatbots for Cancer Treatment Information

Shan Chen, MS[1]; Benjamin H. Kann, MD[1]; Michael B. Foote, MD[2]; Hugo J. W. L. Aerts, PhD[1]; Guergana K. Savova, PhD[3]; Raymond H. Mak, MD[1]; Danielle S. Bitterman, MD[1]

» Author Affiliations | Article Information

JAMA Oncol. 2023;9(10):1459-1462. doi:10.1001/jamaoncol.2023.2954

1/3 of ChatGPT responses were not fully concordant with NCCN guidelines

13% of recommended treatments were hallucinated

JNCI CANCER SPECTRUM
OXFORD UNIVERSITY PRESS

JNCI Cancer Spectr. 2023 Apr; 7(2): pkad015. PMCID: PMC10020140
Published online 2023 Mar 17. doi: 10.1093/jncics/pkad015 PMID: 36929393

Using ChatGPT to evaluate cancer myths and misconceptions: artificial intelligence and cancer information

Skyler B Johnson, MD, Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing,✉ Andy J King, PhD, Conceptualization, Data curation, Formal analysis, Methodology, Writing – review & editing, Echo L Warner, PhD, Formal analysis, Writing – review & editing, Sanjay Aneja, MD, Formal analysis, Writing – review & editing, Benjamin H Kann, MD, Formal analysis, Methodology, Writing – review & editing, and Carma L Bylund, PhD, Conceptualization, Formal analysis, Methodology, Supervision, Writing – review & editing

Will eating sugar make my cancer worse?	are available, the person's overall health, and more. No. Although research has shown that cancer cells consume more sugar (glucose) than normal cells, no studies have shown that eating sugar will make your cancer worse or that, if you stop eating sugar, your cancer will shrink or disappear. However, a high-sugar diet may contribute to excess weight gain, and obesity is associated with an increased risk of developing several types of cancer. For more information, see the NCI fact sheet on Obesity and Cancer.	76	12.7	There is no scientific evidence to support the idea that eating sugar can directly cause cancer or make it worse. However, there is some evidence to suggest that high sugar intake may be associated with an increased risk of certain types of cancer, such as breast and colon cancer. This is because a diet high in sugar is often associated with being overweight or obese, and carrying excess weight has been linked to an increased risk of cancer. Additionally, high sugar intake may be linked to inflammation in the body, which has also been associated with an increased risk of cancer. However, it is important to note that the link between sugar intake and cancer risk is still being studied, and more research is needed to understand the relationship between these factors. It is generally recommended to limit your intake of added sugars, such as those found in sugary drinks, sweets, and baked goods, as part of a healthy diet. This is because a diet high in added sugars has been

5 Oncologist Reviewers

11/13 questions accurate by all 5, 97% agreement

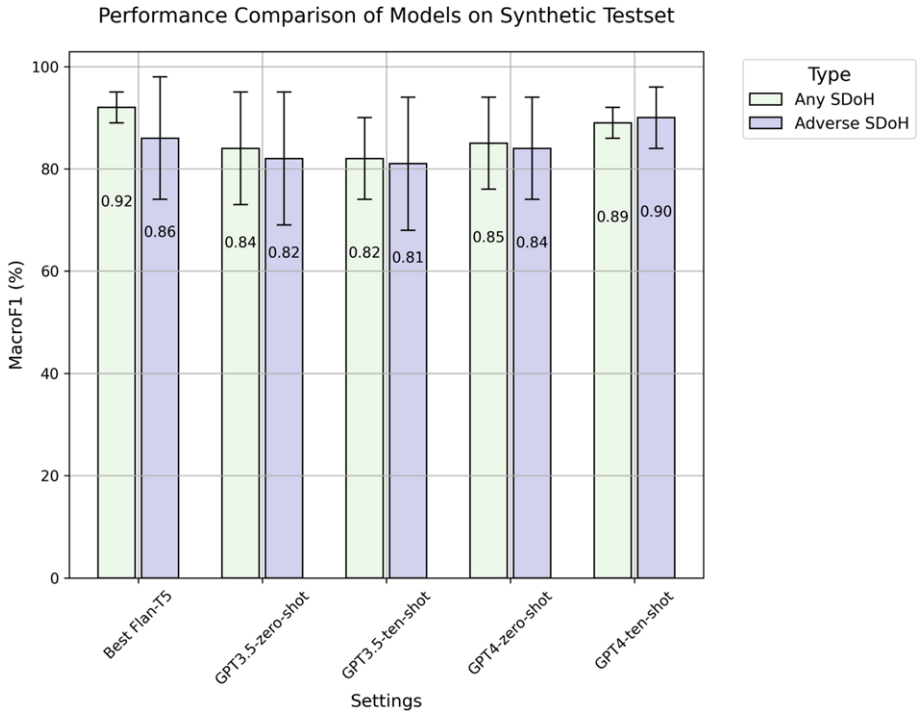
New frontier: LLMs and patient care

Article | Open access | Published: 11 January 2024

Large language models to identify social determinants of health in electronic health records

Marco Guevara, Shan Chen, Spencer Thomas, Tafadzwa L. Chaunzwa, Idalid Franco, Benjamin H. Kann, Shalini Moningi, Jack M. Qian, Madeleine Goldstein, Susan Harper, Hugo J. W. L. Aerts, Paul J. Catalano, Guergana K. Savova, Raymond H. Mak & Danielle S. Bitterman

npj Digital Medicine **7**, Article number: 6 (2024) | Cite this article



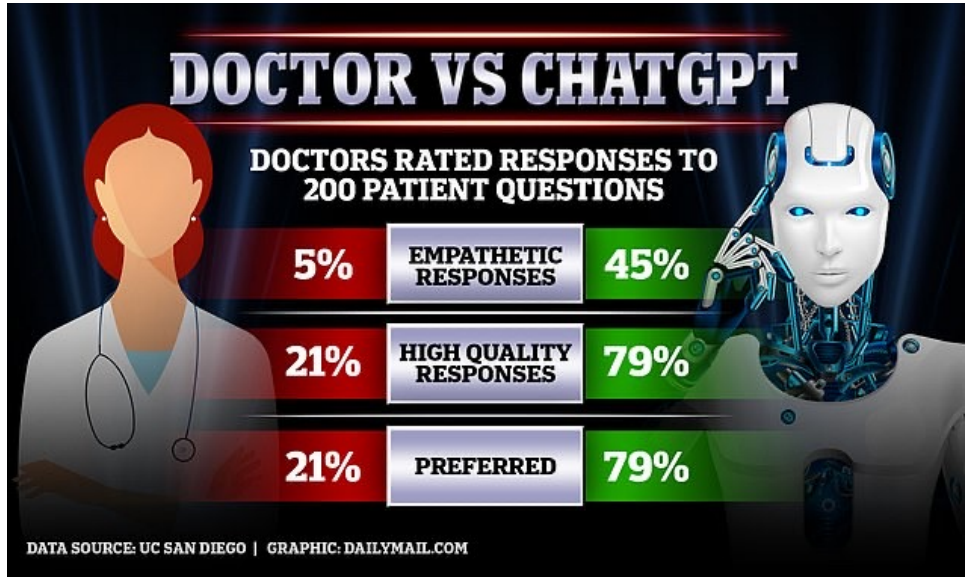
Original Investigation

ONLINE FIRST

April 28, 2023

Comparing Physician and Artificial Intelligence Chatbot Responses to Patient Questions Posted to a Public Social Media Forum

John W. Ayers, PhD, MA[1,2]; Adam Poliak, PhD[3]; Mark Dredze, PhD[4]; et al



Acknowledgements

Artificial Intelligence in Medicine (AIM) Program, Mass General Brigham

Hugo Aerts, PhD
Christian Guthier, PhD
Ray Mak, MD
Danielle Bitterman, MD

Dana-Farber / Brigham and Women's Cancer Center, Harvard Medical School

Daphne-Haas Kogan, MD MBA
Tabitha Cooney, MD
Tina Poussaint, MD
Jon Schoenfeld, MD
Danielle Margalit, MD

CBTN / PNOC

Sabine Mueller, MD
Adam Resnick, PhD
Ali Nabavidazeh, MD
Ariana Familiar PhD

AIM: Kann Lab

Jirapat Likitlersuang
Zezhong Ye
Frank Hoebers
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CBTTC Children's Brain Tumor Network