



Universität
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USZ Universitäts
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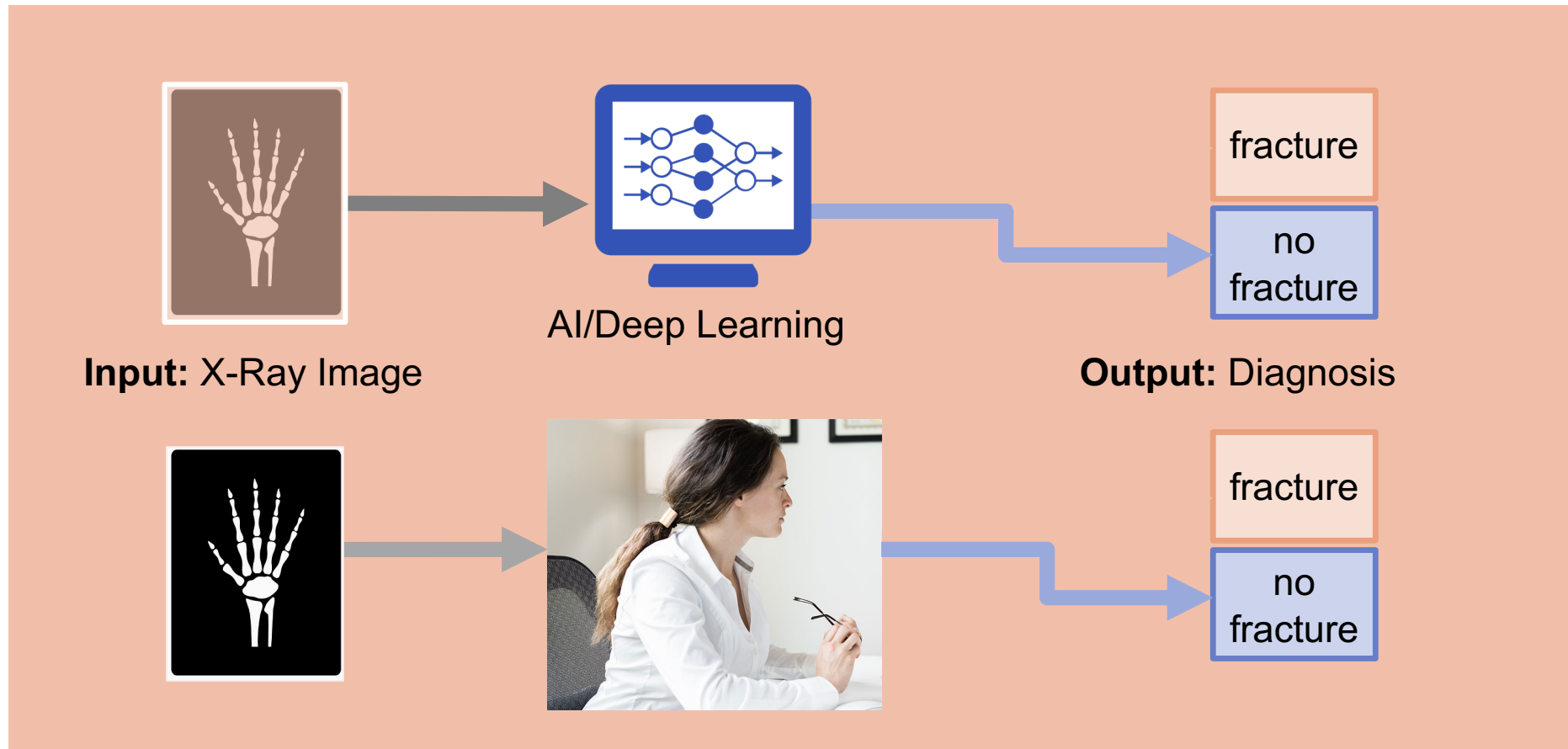
Institut für Quantitative Biomedizin | Lehrstuhl Medizininformatik

Medical Informatics and AI – the Future of Healthcare

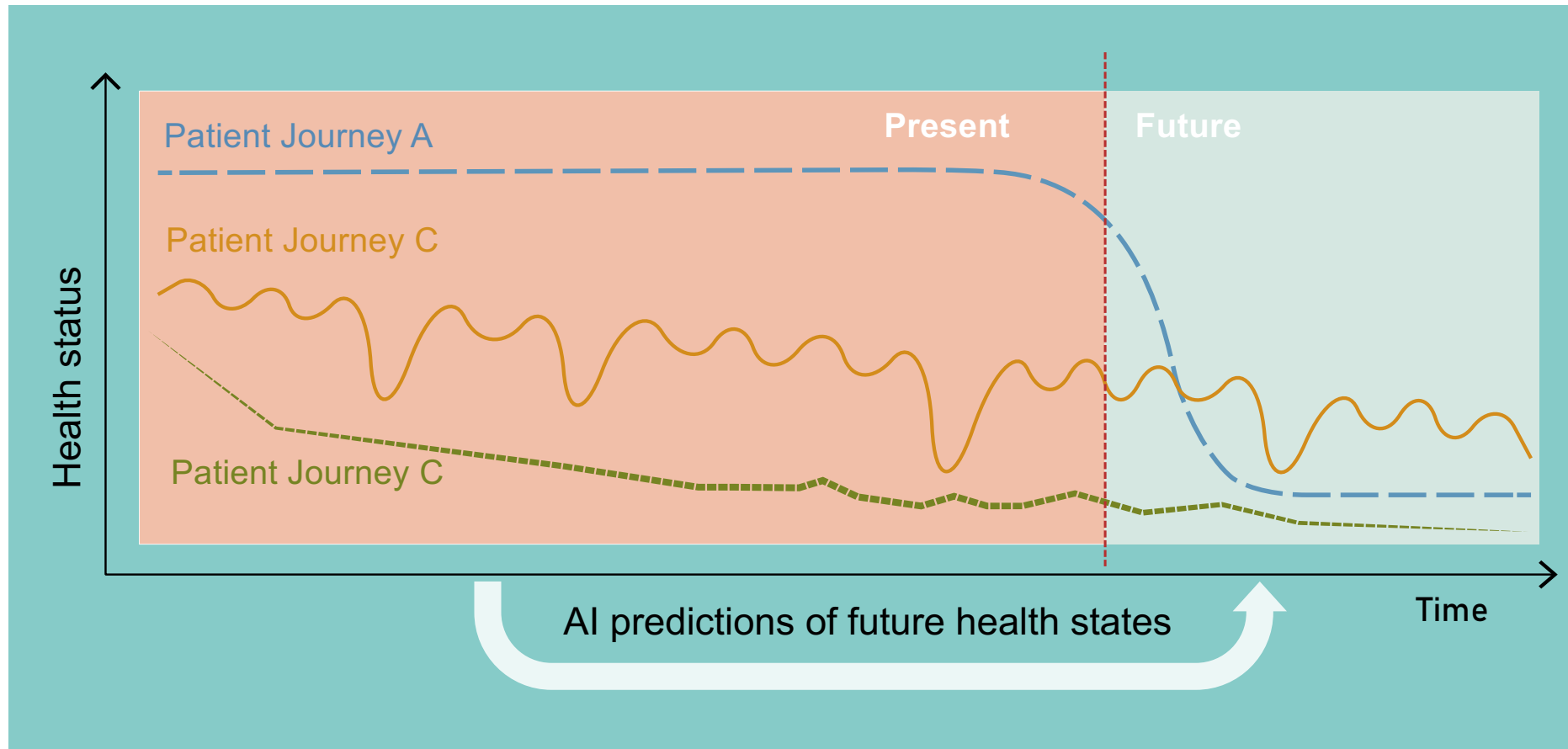
Michael Krauthammer, MD PhD

10/03/2024

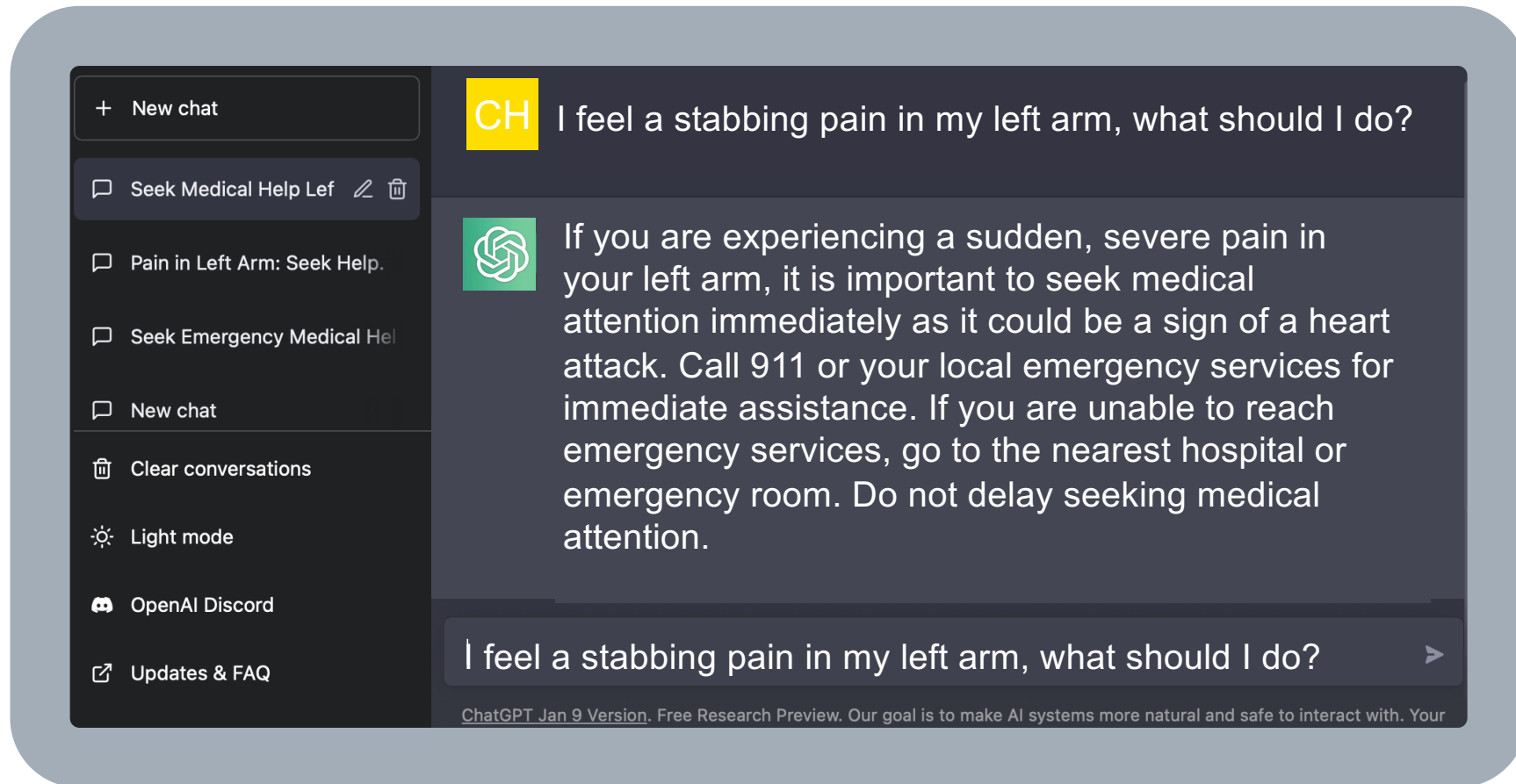
Emulating Expert Thinking with AI



AI: AI Predictions of Health States



AI: Conversational Language Models



Bigger and Bigger Language Models

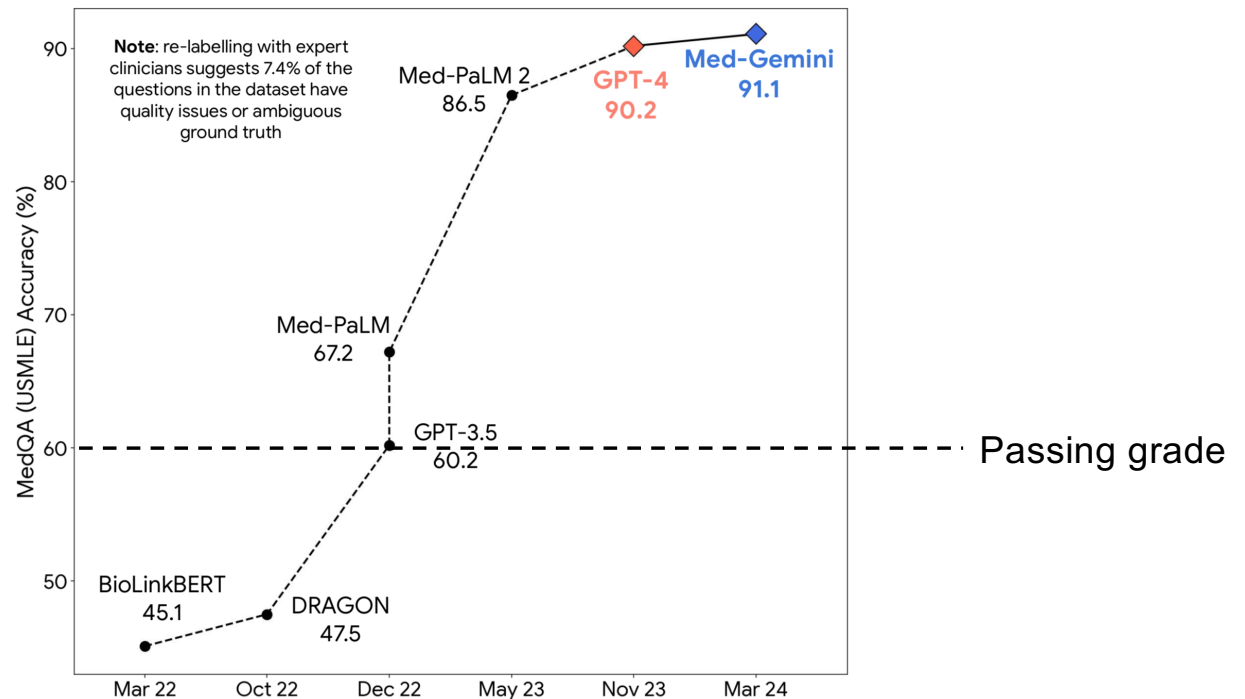
Big models (parameters):

GPT-3.5: 175 billion

GPT-4: >1 Trillion

Big data:

Med-Gemini: Trillions of tokens;
specialized medical data sets
(radiology, pathology)



Towards Multimodal Language («Foundation») Models

Nature

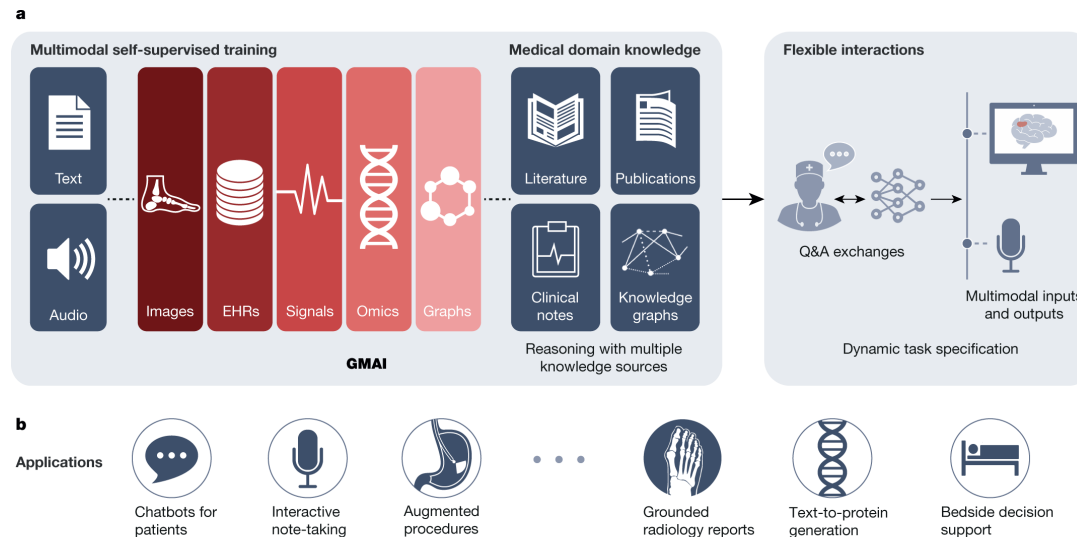
Perspective

Foundation models for generalist medical artificial intelligence

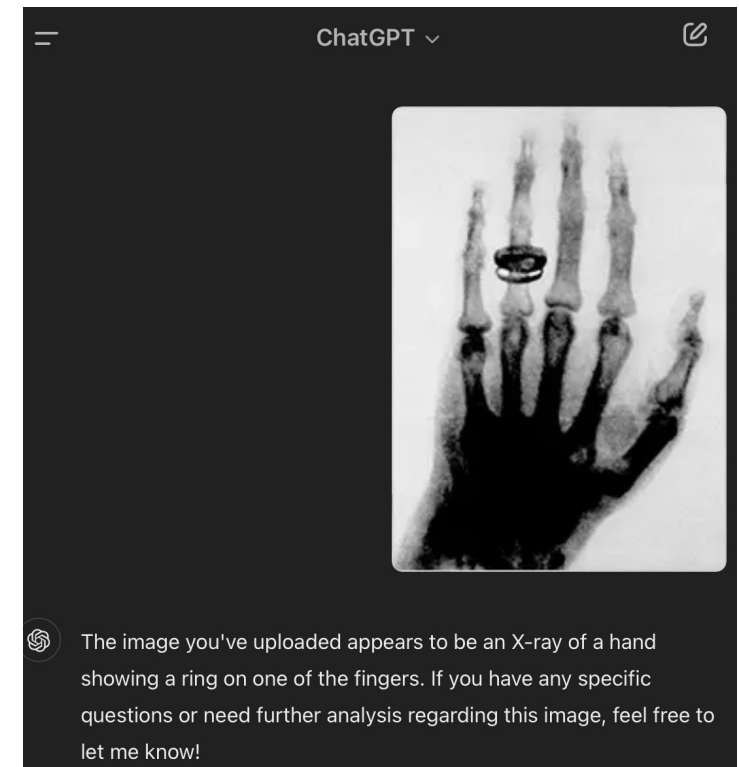
<https://doi.org/10.1038/s41586-023-05881-4>

Received: 3 November 2022

Michael Moor^{1,6}, Oishi Banerjee^{2,6}, Zahra Shakeri Hossein Abad³, Harlan M. Krumholz⁴, Jure Leskovec¹, Eric J. Topol^{5,7,8} & Pranav Rajpurkar^{2,7,8}



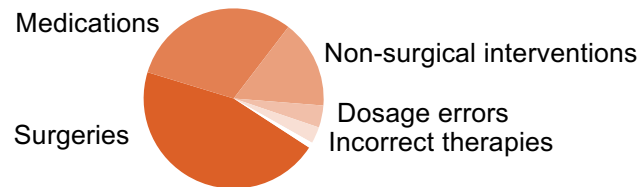
Regulations: Application approval; validation; audits; community-based challenges; analyses of biases, fairness and diversity



AI: Solution for Healthcare Problems?

Quality of Dx and Therapy

Complications in relation to

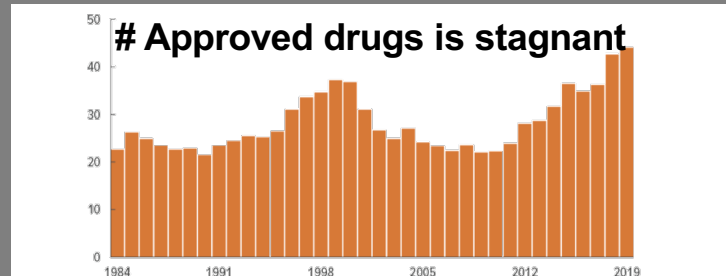


Workforce

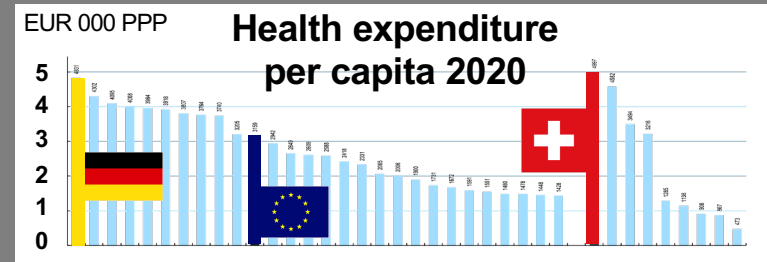


Swiss Media report in September 2021

Switzerland will be short of 20,000 healthcare workers by 2030



Innovation



Healthcare costs

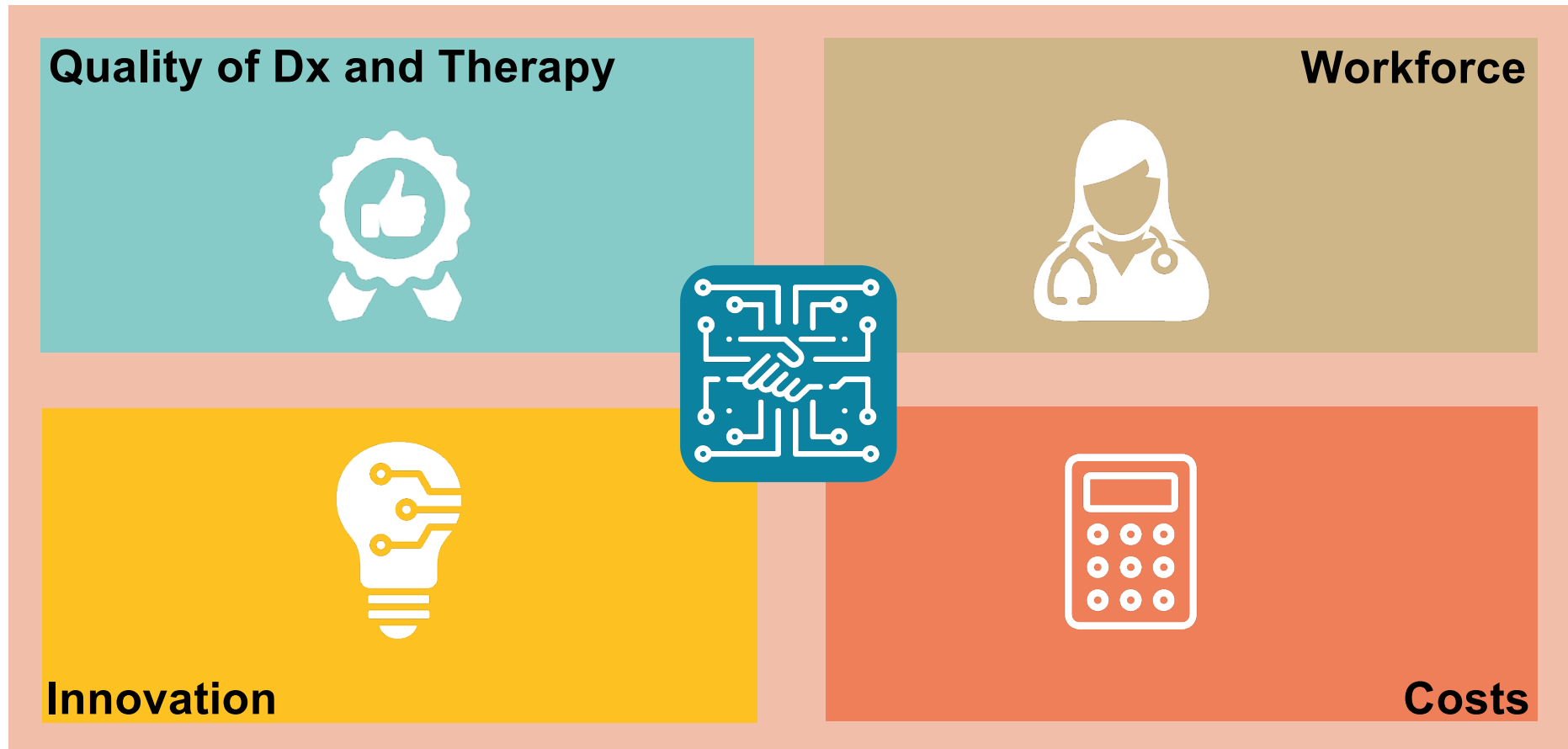
Sources: Beobachter Gesundheit

Report of the Congressional Budget Office 3/8/2021

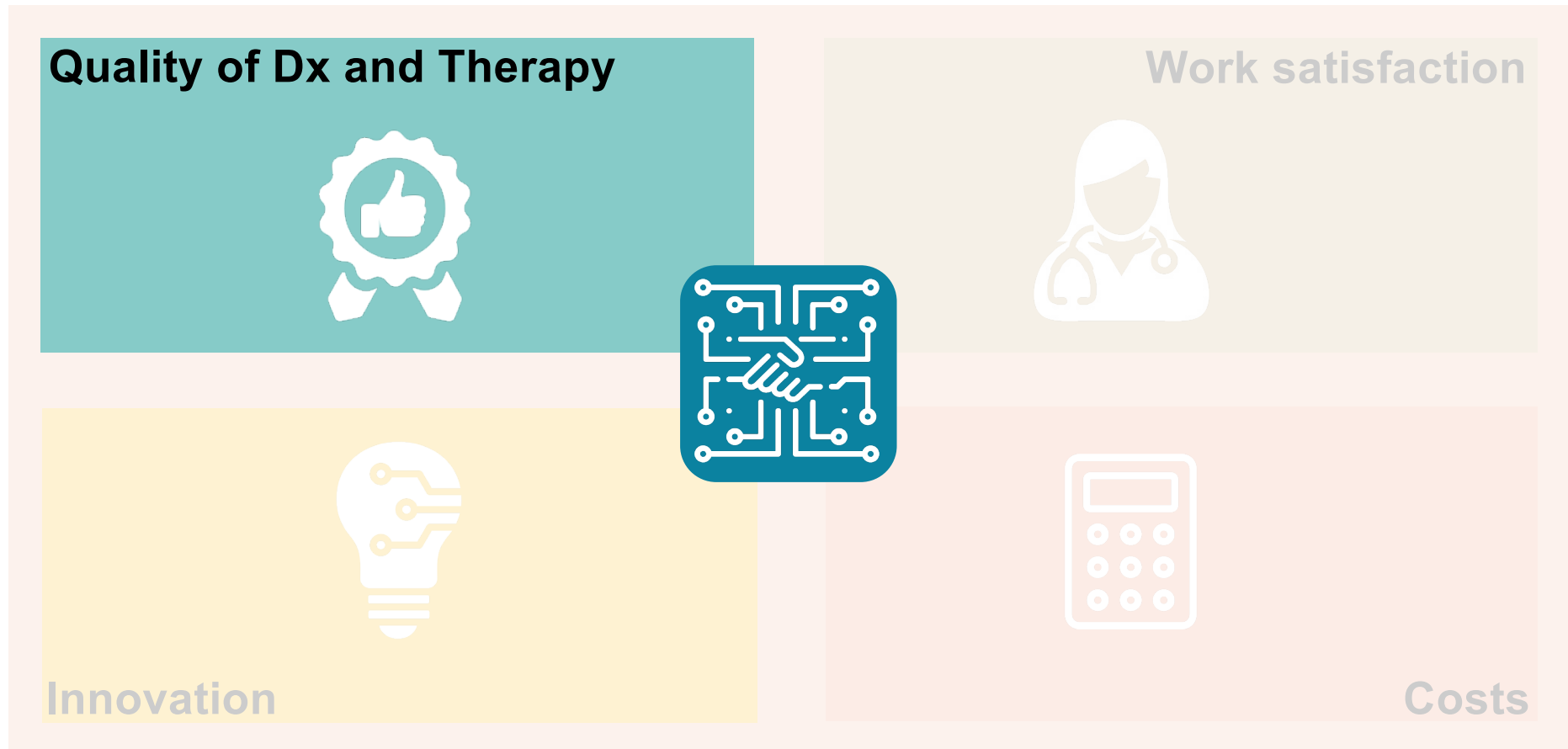
Tagesanzeiger

Health expenditure per capita

AI: Solution for Healthcare Problems?



AI: Solution for Healthcare Problems?



AI Reaches Physician-Level Diagnostic Performance

2017

Dermatology

Melanoma Detection

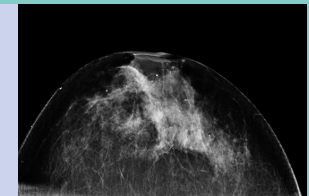
“better or *en par* with 21 dermatologists”



2019/20

Radiology

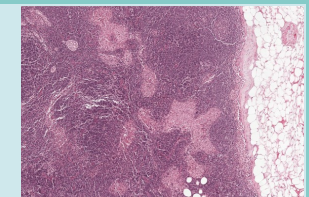
Breast Cancer Dx



2019/20

Pathology

Prostate Carcinoma Dx

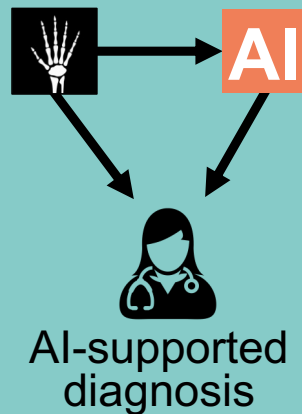


Disciplines with Big Data collections

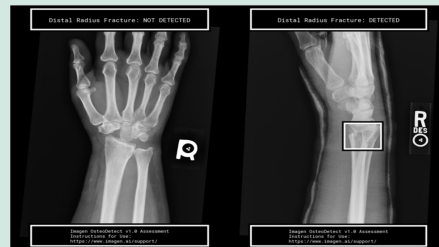
AI assisting Physicians in Improving Care Quality

2021 Several commercial AI systems available

AI Assistant



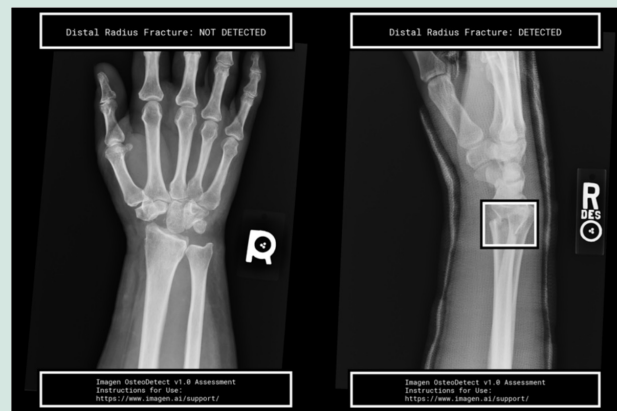
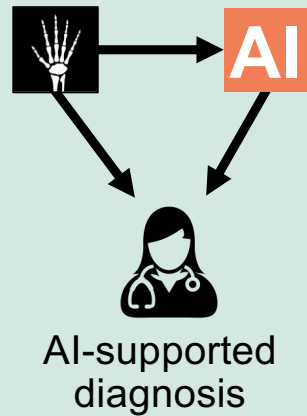
OsteoDetect



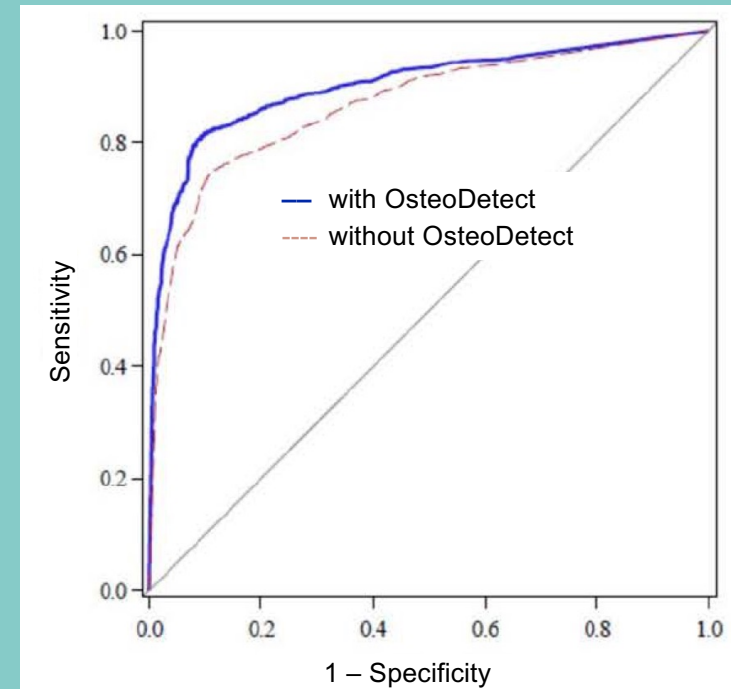
Detect Fractures in radiology images

AI assisting Physicians in Improving Care Quality

Example OsteoDetect



Physician performance
increased 4-5% with AI



Sensitivity (true positive rate) is the probability of a positive test result, conditioned on the individual truly being positive.

Specificity (true negative rate) is the probability of a negative test result, conditioned on the individual truly being negative.

Clinical Data Science: Case Study 1

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HÔPITAL UNIVERSITAIRE DE BERNE

Rheumatology, 2023, **62**, 2492–2500
<https://doi.org/10.1093/rheumatology/keac541>
Advance access publication 9 November 2022
Original article






British Society for
Rheumatology

RHEUMATOLOGY



Clinical science

Vision transformer assisting rheumatologists in screening for capillaroscopy changes in systemic sclerosis: an artificial intelligence model

Alexandru Garaiman^{1,†}, Farhad Nooralahzadeh^{2,†}, Carina Mihai¹, Nicolas Perez Gonzalez², Nikitas Gkikopoulos¹, Mike Oliver Becker ¹, Oliver Distler ¹, Michael Krauthammer^{2,‡}, Britta Maurer ^{1,3,*}

¹Department of Rheumatology, University Hospital Zurich, University of Zurich, Zurich, Switzerland

²Department of Quantitative Biomedicine, University of Zurich, Zurich, Switzerland

³Department of Rheumatology and Immunology, University Hospital Bern, University of Bern, Bern, Switzerland

*Correspondence to: Britta Maurer, Department of Rheumatology and Immunology, University Hospital Bern, University of Bern, Freiburgstrasse 16p, 3010 Bern, Switzerland. E-mail: britta.maurer@insel.ch

[†]Alexandru Garaiman and Farhad Nooralahzadeh contributed equally to this study.

[‡]Michael Krauthammer and Britta Maurer contributed equally to this study.



Farhad
Nooralahzadeh



Britta
Maurer

Early detection of systemic sclerosis (SSc) using Nailfold Capillaroscopy

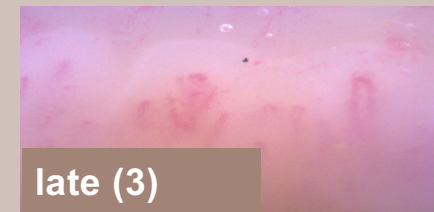
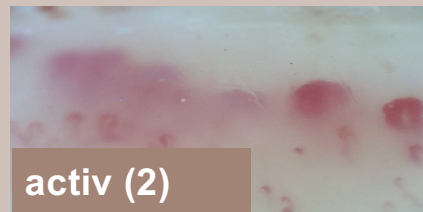
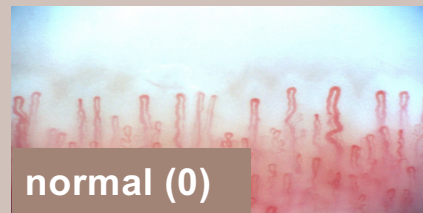
“ViT with near human level performance”: Will assist rheumatologist in examining patients

Capillary Microscopy

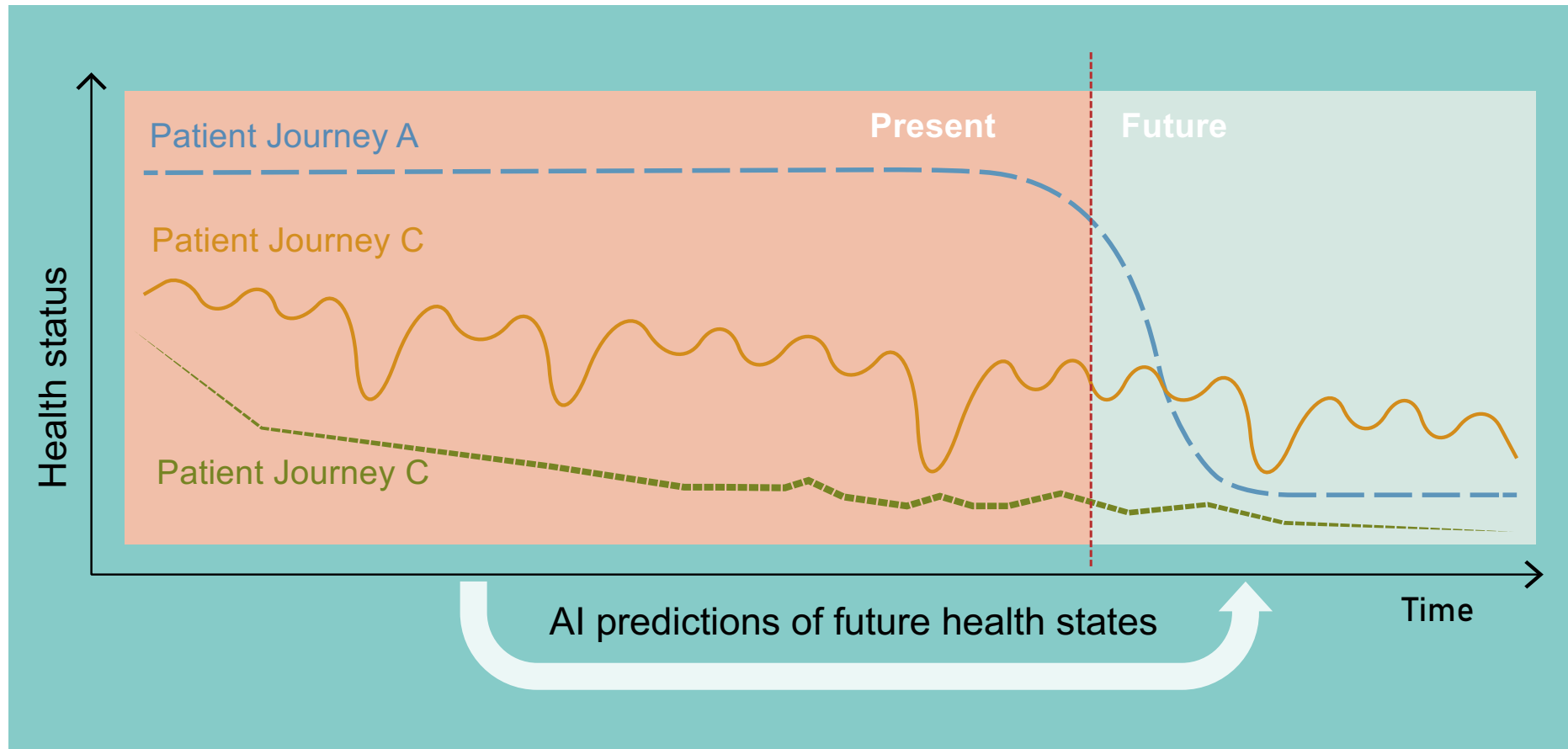
Microscopic examination of the nailfold



Findings: normal/pathologic shape of the capillaries



AI Predictions of Future Health States



AI Predictions of Future Health States

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FNSNF
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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Innosuisse – Schweizerische Agentur
für Innovationsförderung



Ahmed Allam



Cécille Trottet



Rita Maurer



Oliver Distler



Reto Schüpbach

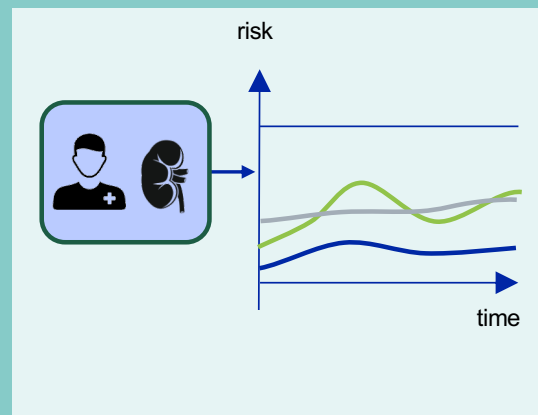


Emanuela Keller

Prediction of **delirium** in the
ICU



Prediction of **transplant**
rejection after kidney tr.



Disease activity prediction in
inflammatory joint diseases



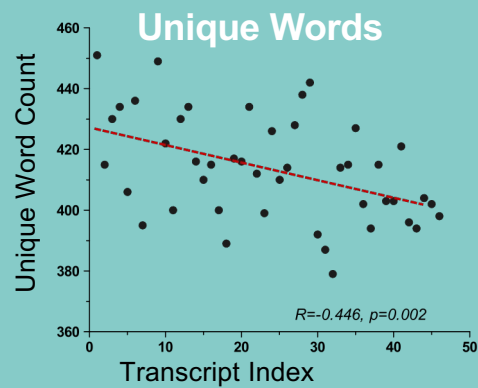
<https://www.masimo.com/solutions/perioperative/icu/>

<https://www.morethanscleroderma.com>

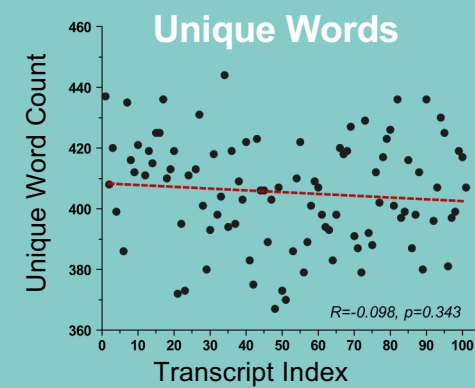


Voice-Based AI Diagnosis

Ronald Reagan



George H.W. Bush

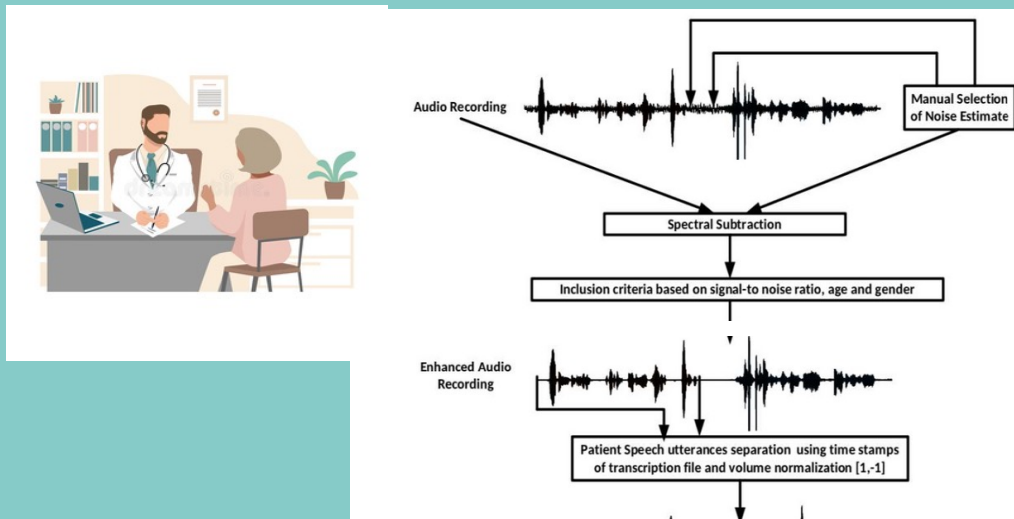


V. Berisha V et al. Tracking Discourse Complexity Preceding Alzheimer's Disease Diagnosis: A Case Study, 2015

14/9/23

Page 17

Voice-Based AI Diagnosis



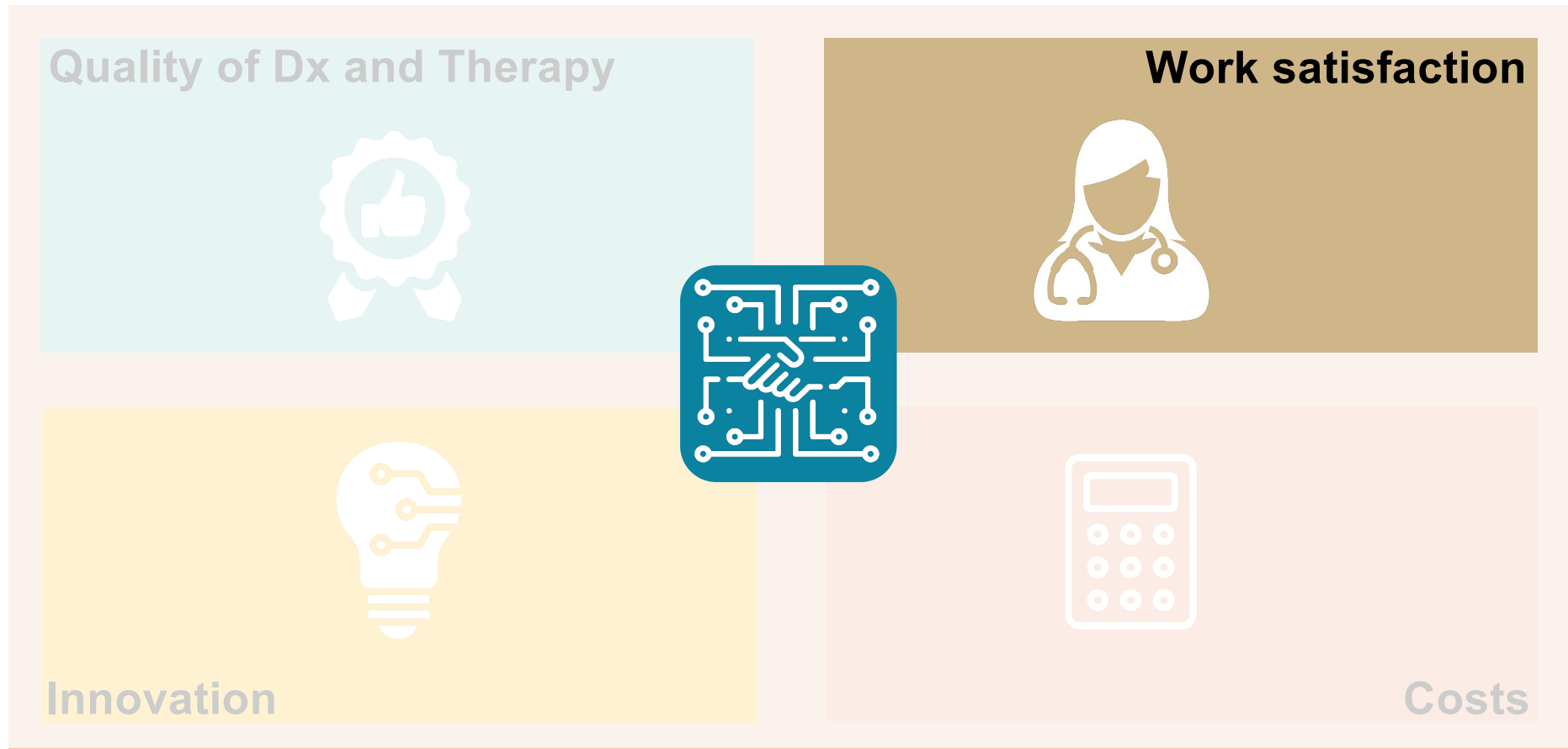
Morteza Rohanian Philipp Hohman

Cognitive State (Dementia, Schizophrenia...)

Rohanian, Morteza. "Multimodal Assessment of Cognitive Decline", 2021

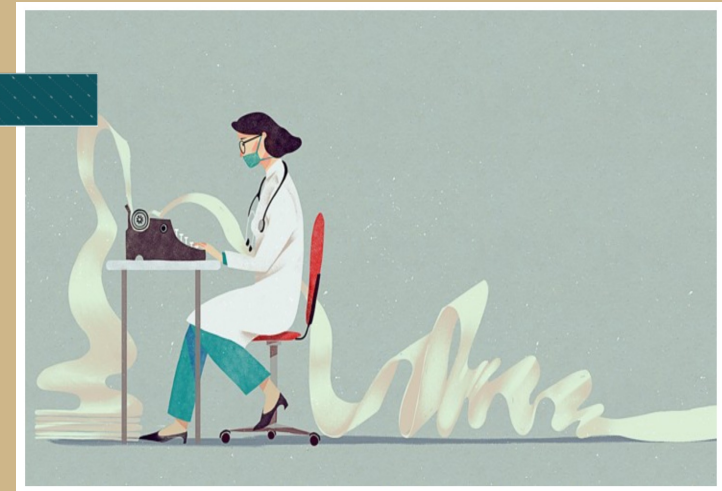
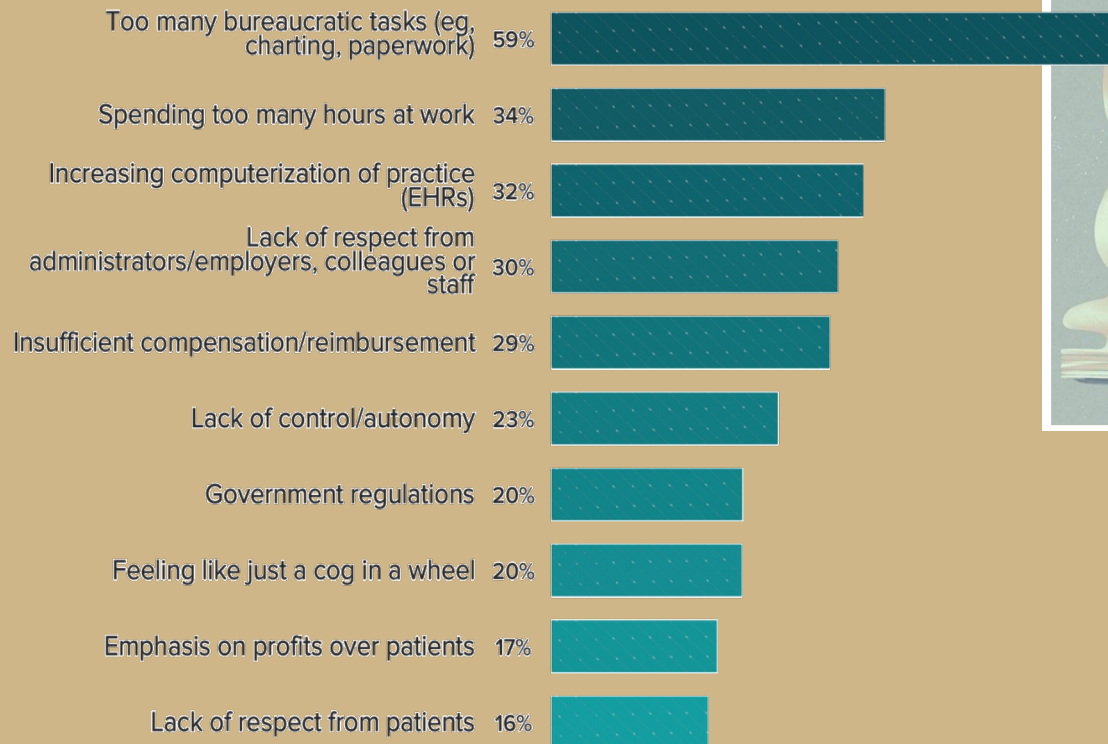
de la Fuente García, Sofia. "Investigating speech technology for monitoring disease progression in the context of neurodegenerative disease." (2021).

AI and Work Satisfaction



AI Composes the Medical Report

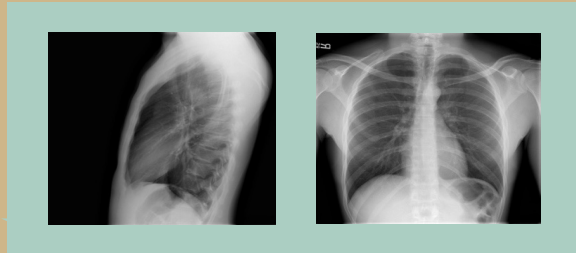
What contributes most to your burnout?



AI Composes the Medical Report

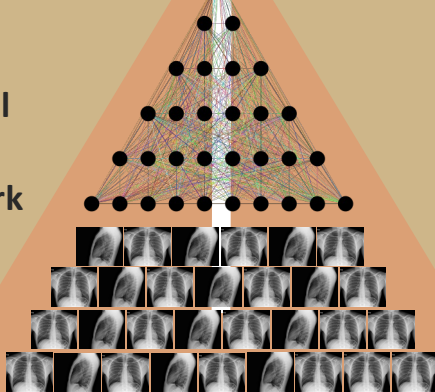


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AI

Artificial
Neural
Network



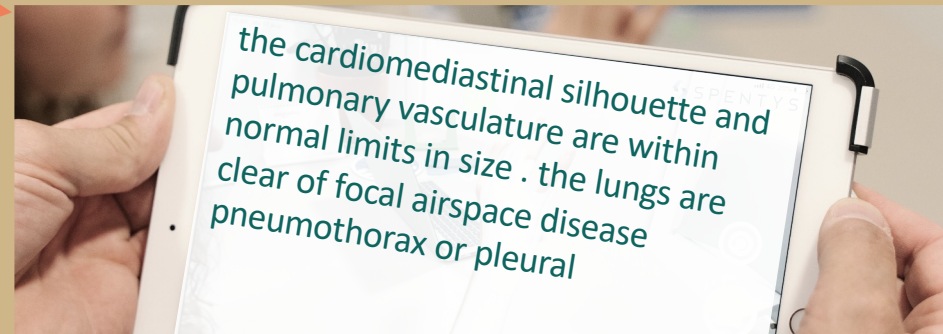
Farhad
Nooralahzadeh



Koji
Fujimoto



Thomas
Frauenfelder



AI Composes the Medical Report



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Empirical Methods in Natural Language
Processing (EMNLP) 2021



Farhad
Nooralahzadeh



Koji
Fujimoto



Thomas
Frauenfelder

Progressive Transformer-Based Generation of Radiology Reports

**Farhad Nooralahzadeh¹, Nicolas Perez Gonzalez¹, Thomas Frauenfelder¹,
Koji Fujimoto^{2†}, Michael Krauthammer¹**

¹University of Zürich and University Hospital of Zürich, ²Kyoto University
{farhad.nooralahzadeh,nicolas.perez,michael.krauthammer}@uzh.ch
thomas.frauenfelder@usz.ch, [†]kfb@kuhp.kyoto-u.ac.jp

AI Composes the Medical Report

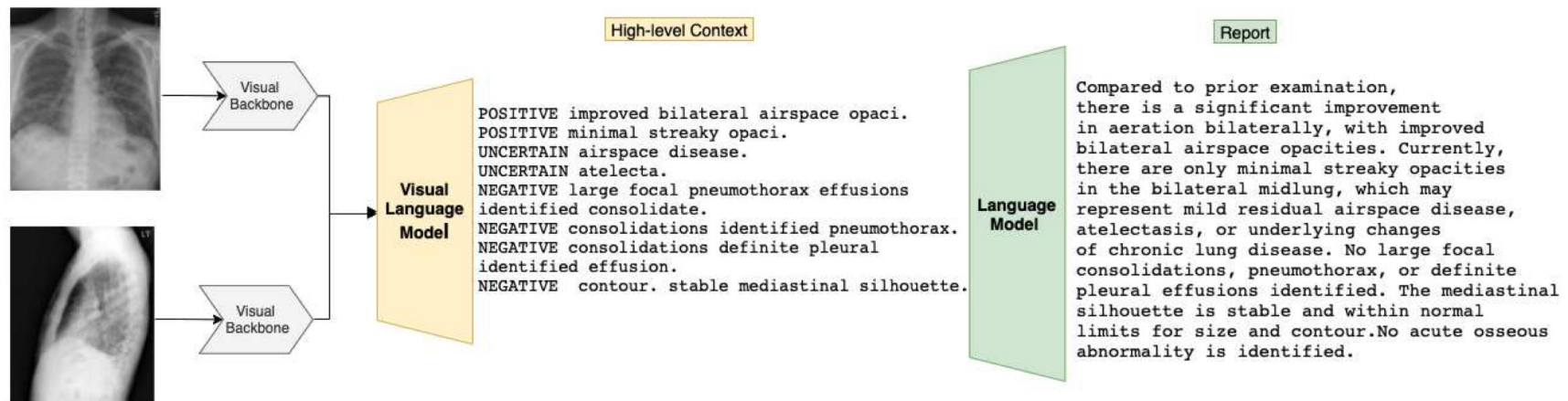


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Image captioning model, Transformer-based

Sequence-to-sequence model, BART



DenseNet (pre-trained convolutional neural network, ImageNet)

Towards a Multi-Lingual Radiology Assistant



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USER: *Where is the trachea located on the X-ray?*

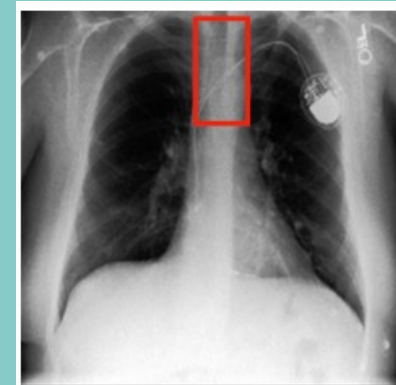
ASSISTANT: *The trachea is situated at [0.46, 0.55, 0.63, 0.98] in the image*

USER: *What abnormalities can you find in this image?*

ASSISTANT: *From the examination, I can find the following abnormalities: support devices*

USER: *Please give a detailed report from this Chest X-ray*

ASSISTANT: *The heart is mildly enlarged (...) No pneumothorax or pulmonary edema*



Bei der Untersuchung kann ich folgende Auffälligkeiten feststellen

検査の結果、以下の異常が見つかりました:
サポートデバイス

Towards a Multi-Lingual Radiology Assistant

Top Challenge:

Access to GPU Computers !

SWISS AI Initiative

Infrastructure Research Steering Committee Researchers

**Leveraging the world's most
AI-capable supercomputer**

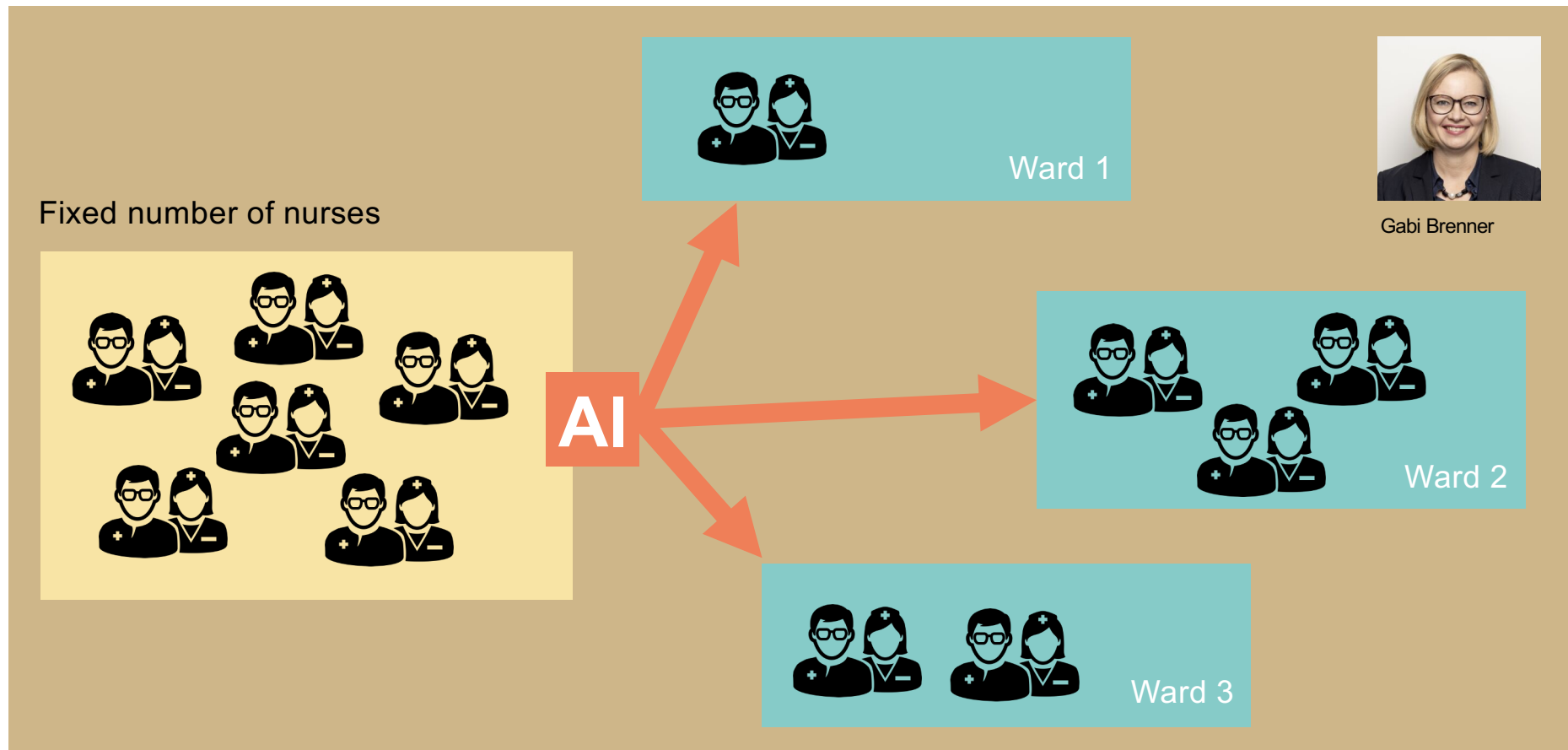
Alps by the National Supercomputing Center (CSCS) is the world's first national research infrastructure with over 10'000 GPUs of the new NVIDIA Grace Hopper superchip.



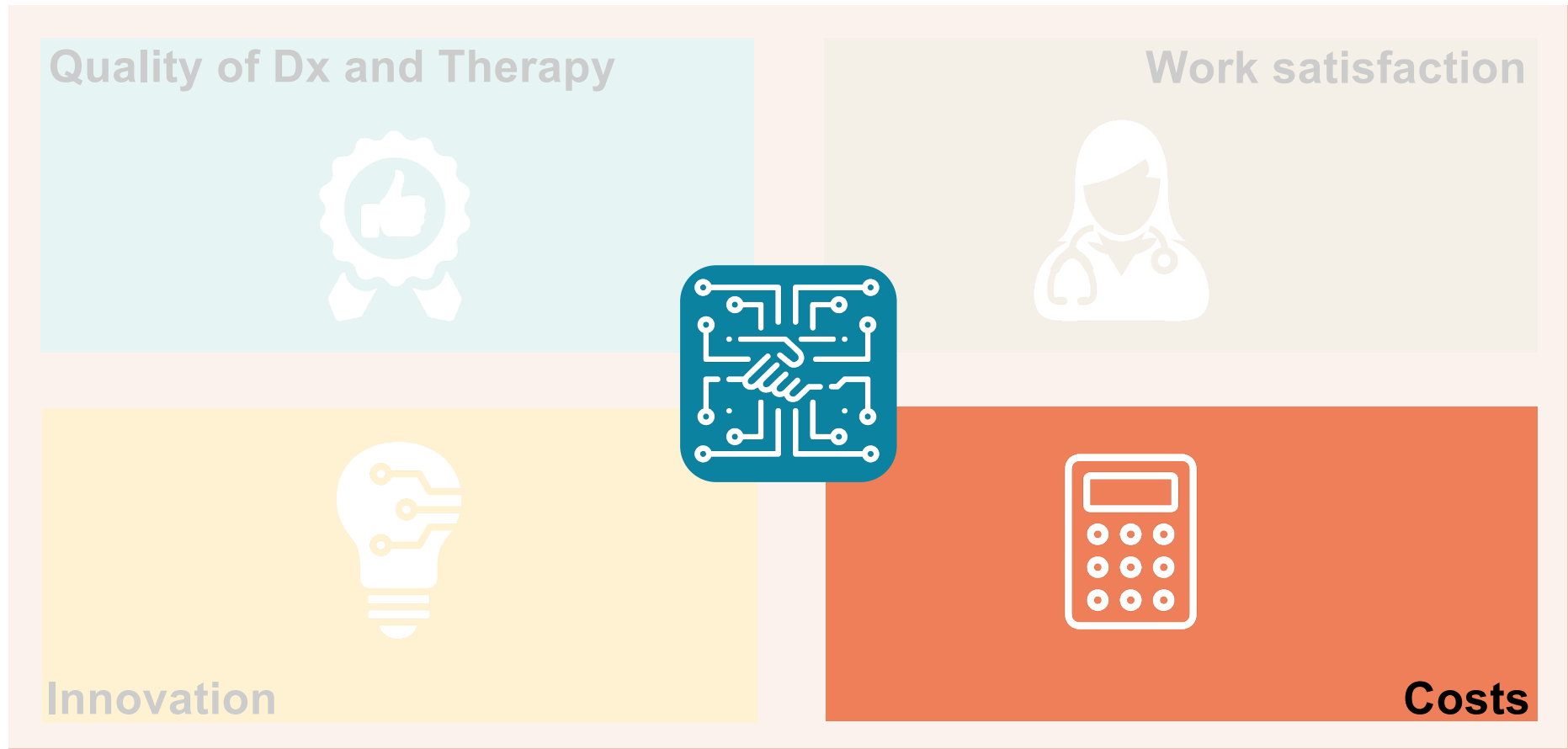
Improving Resource Allocation in Nursing with AI



Gabi Brenner

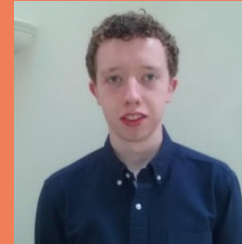


AI to Curb Healthcare Costs

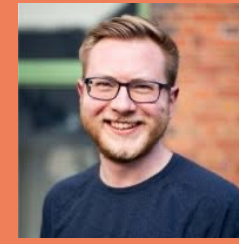


AI for Smarter Hospital Processes

Improved MRI Usage



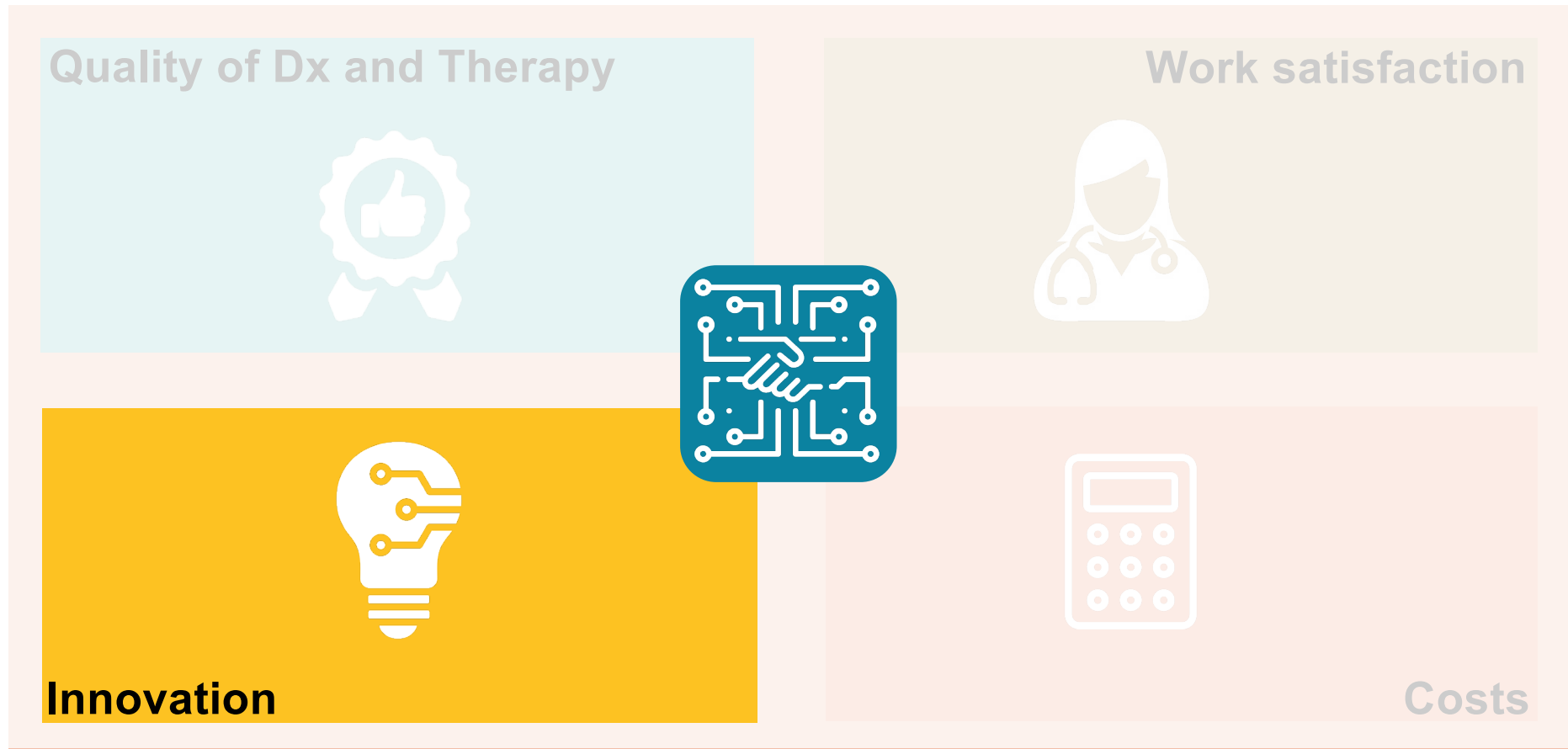
Mark McMahon



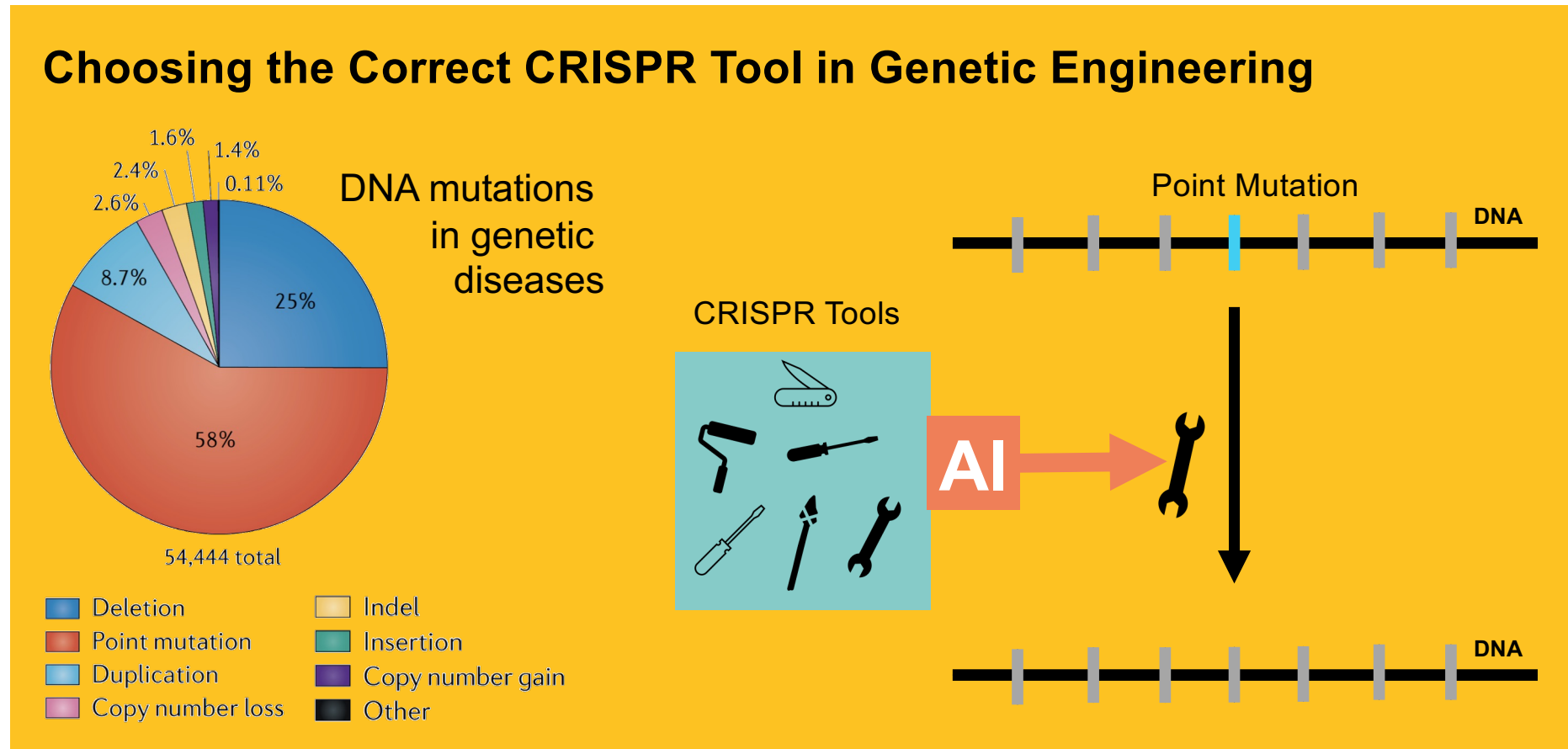
Jonas Kluckert

- USZ MRI machines are 17% idle (not booked) during day
- Substantial costs / missed income
- We are building an AI application that identifies patients that will likely miss their appointment
- These patients receive targeted appointment reminders

AI to Accelerate Health Innovation



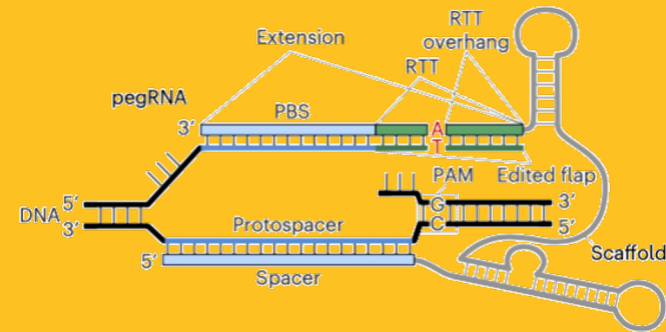
AI for Finding Cures for Genetic Disease



Data from: Rees et al., 2018

AI for Finding Cures for Genetic Disease

Choosing the Correct CRISPR Tool in Genetic Engineering



nature biotechnology

2023

Article

<https://doi.org/10.1038/s41587-022-01613-7>

Predicting prime editing efficiency and product purity by deep learning

Received: 5 April 2022

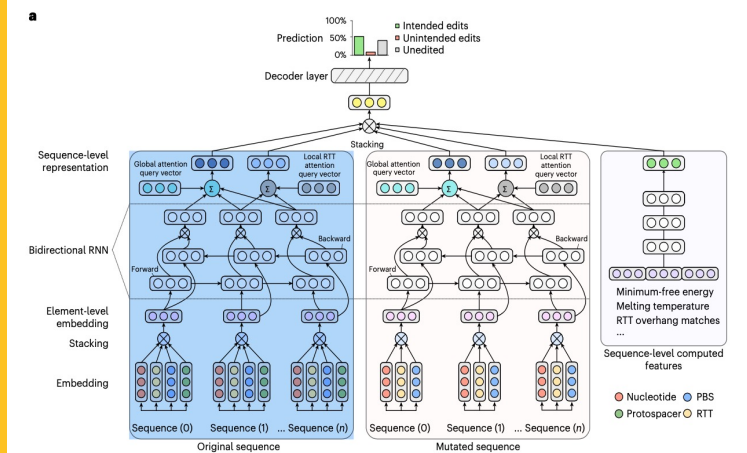
Accepted: 15 November 2022

Published online: 16 January 2023

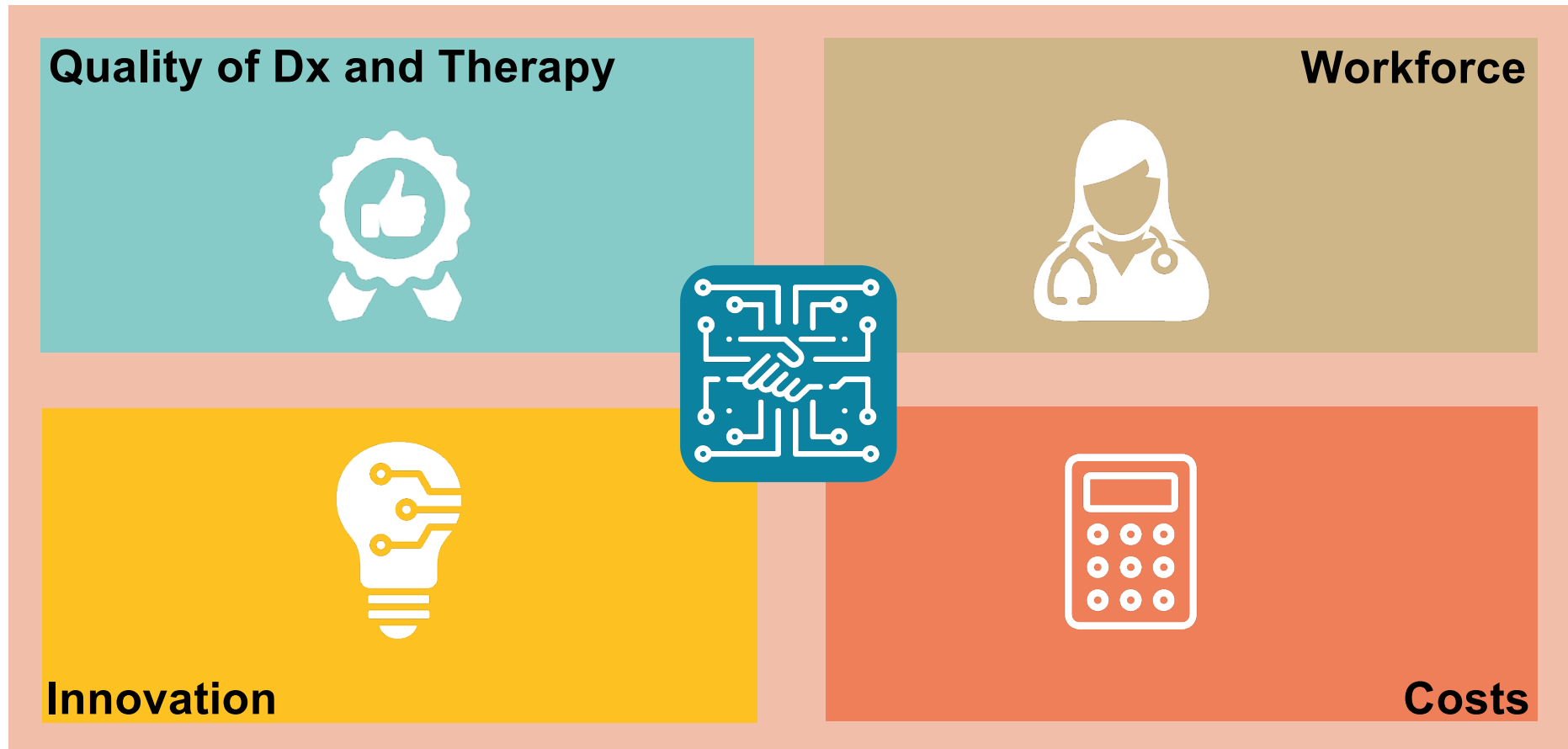
Check for updates

Nicolas Mathis^{1,4}, Ahmed Allam^{2,4}, Lucas Kissling¹,
Kim Fabiano Marquart^{1,3}, Lukas Schmidheini^{1,3}, Cristina Solari¹,
Zsolt Balázs², Michael Krauthammer²✉ & Gerald Schwank¹✉

Prime editing is a versatile genome editing tool but requires experimental optimization of the prime editing guide RNA (pegRNA) to achieve high



AI: Solution for Healthcare Problems?



Can we trust AI with regard to medical decisions?

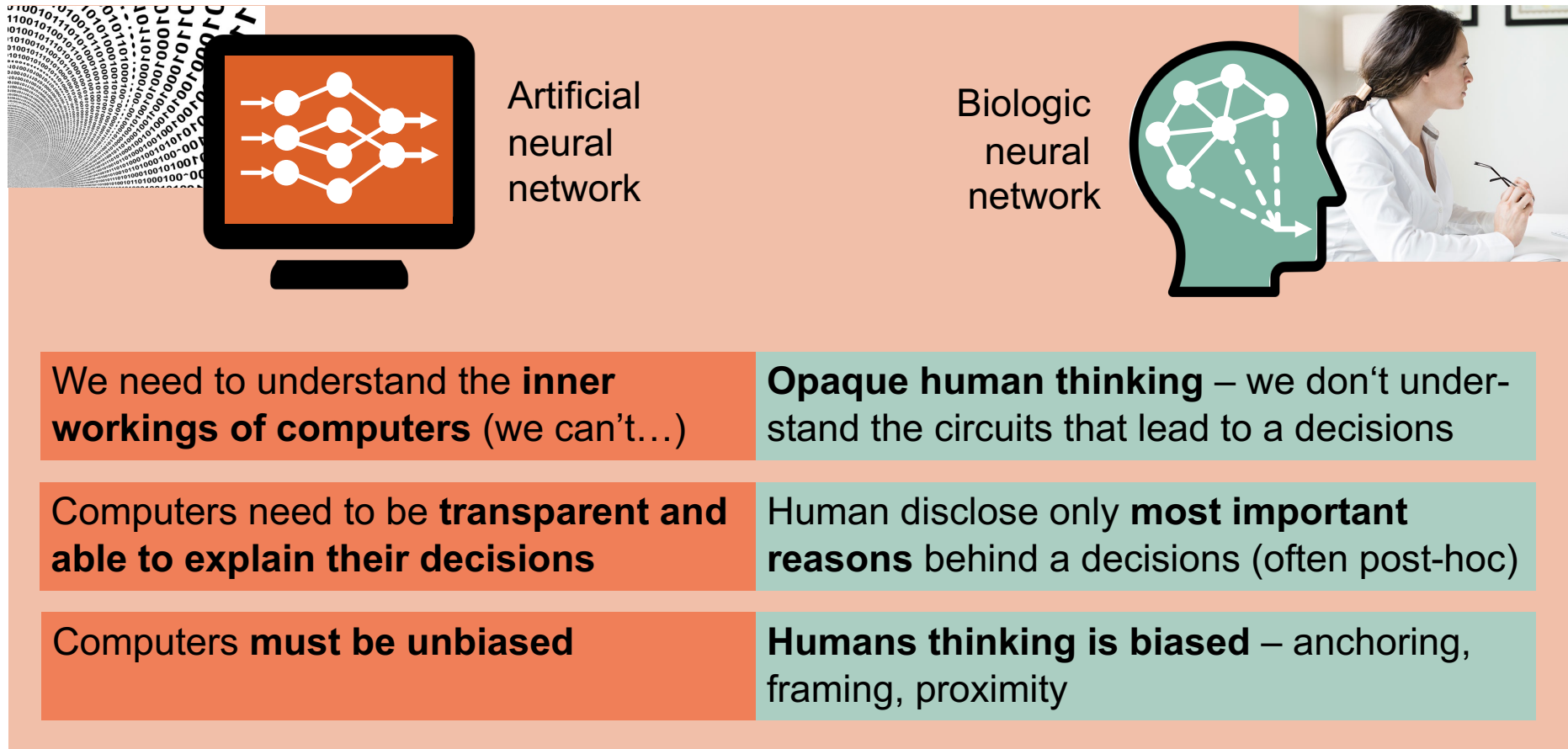


- The inner working of computers are not clear
- Computers cannot explain themselves
- Computers are biased

DALL-E 28.1.2023: "Can we trust computers to make life and death decisions?"



Trust & Medical AI: Is There a Double Standard?

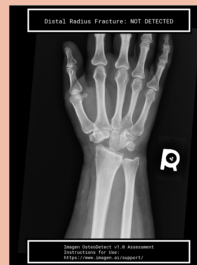


Trust & Medical AI: It is Possible...

AI algorithms should be **reliable**



Fracture ✓



Fracture ✓

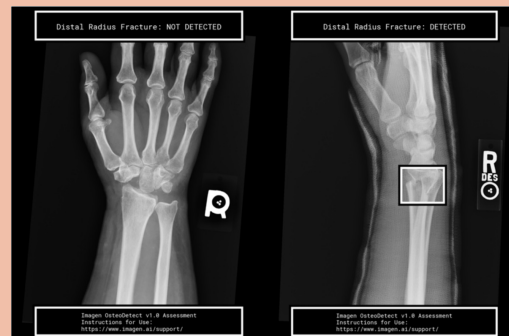


Fracture ✓



Fracture ✓

AI algorithms should **provide explanations**



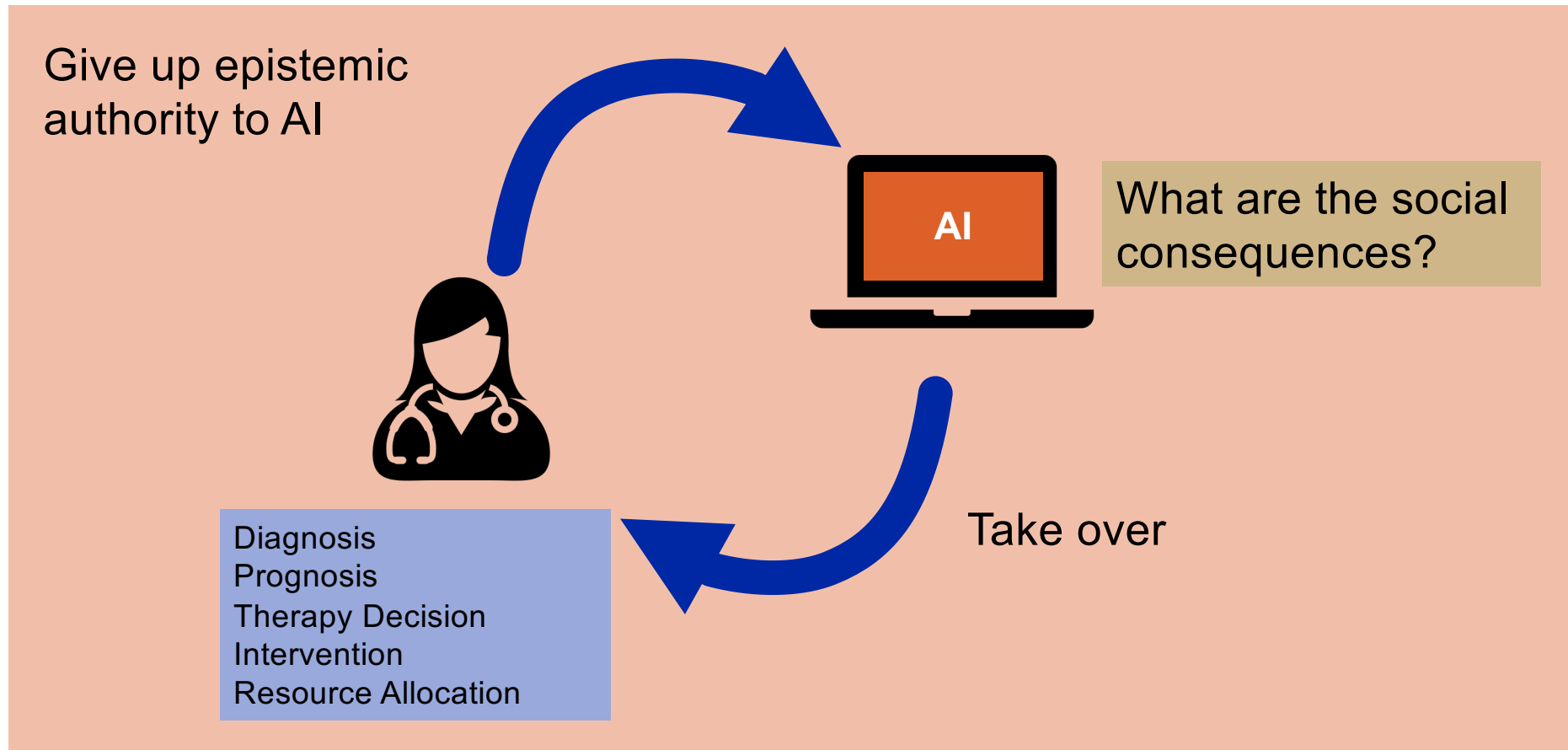
Visual clue

AI, Societal Changes and the Future of Medicine



DALL-E "AI will improve medicine" 28.1.2023

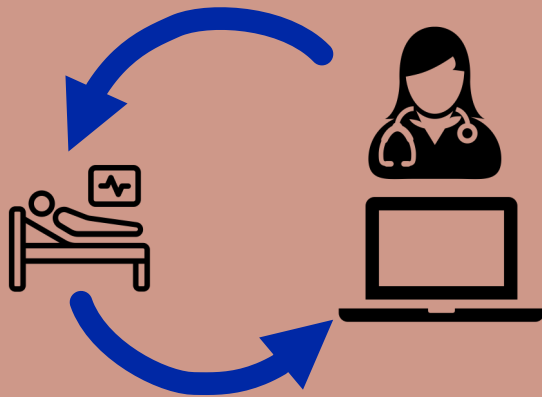
Will Physicians Remain the Sole Authority in Medicine?



Gradual Loss of Epistemic Authority

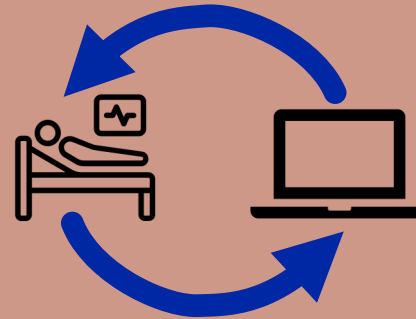
Next 25 years: **small shift in epistemic authority**

- *AI will take on established and recognizable tasks* in the current healthcare delivery process
- In support of physicians and health care providers



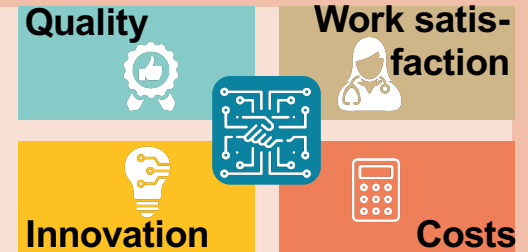
25 years plus: **large shift in epistemic authority**

- Computers operate beyond human understanding of disease
- Decisions without human interventions

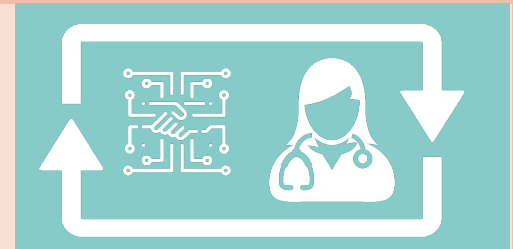


Summary

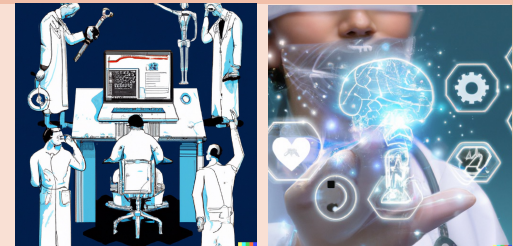
1 **AI** can address current problems in healthcare!



2 AI-guided medical decision: **trust via reliable algorithms and humans in the loop**



3 AI will likely lead to a **large transformation** of medicine as we know it today!



Questions?



krauthammerlab.ch