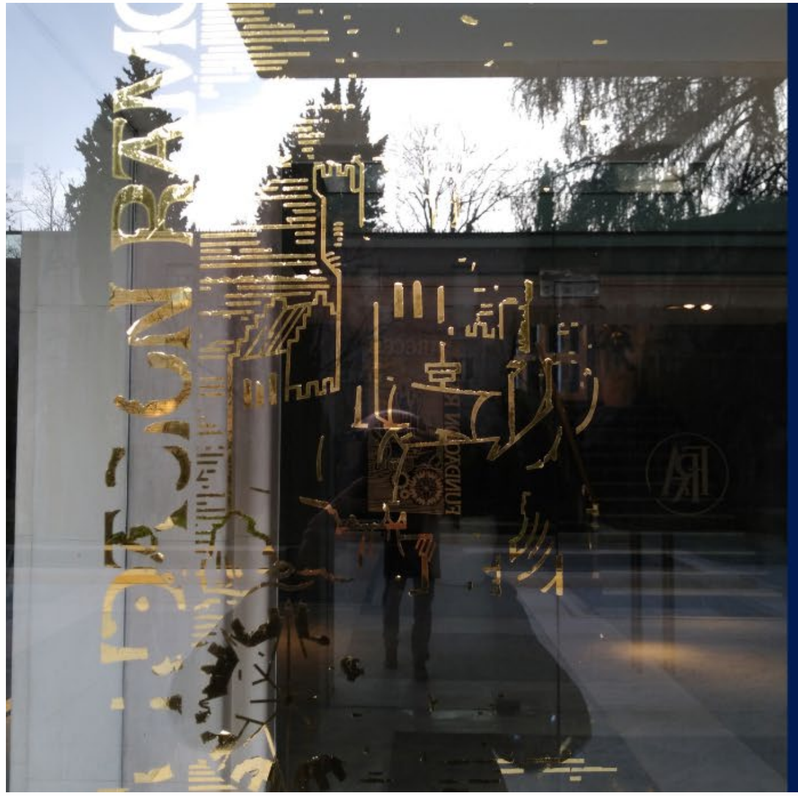


A FIABLE
retos técnicos, éticos, legales, culturales y socio-económicos

SOCIAL IMPACT OF AI

TELSEC4TAI

09.30 AM
30-31 May, 2024

CiTiUS
Centro Singular de Investigación en Tecnoloxías Intelixentes

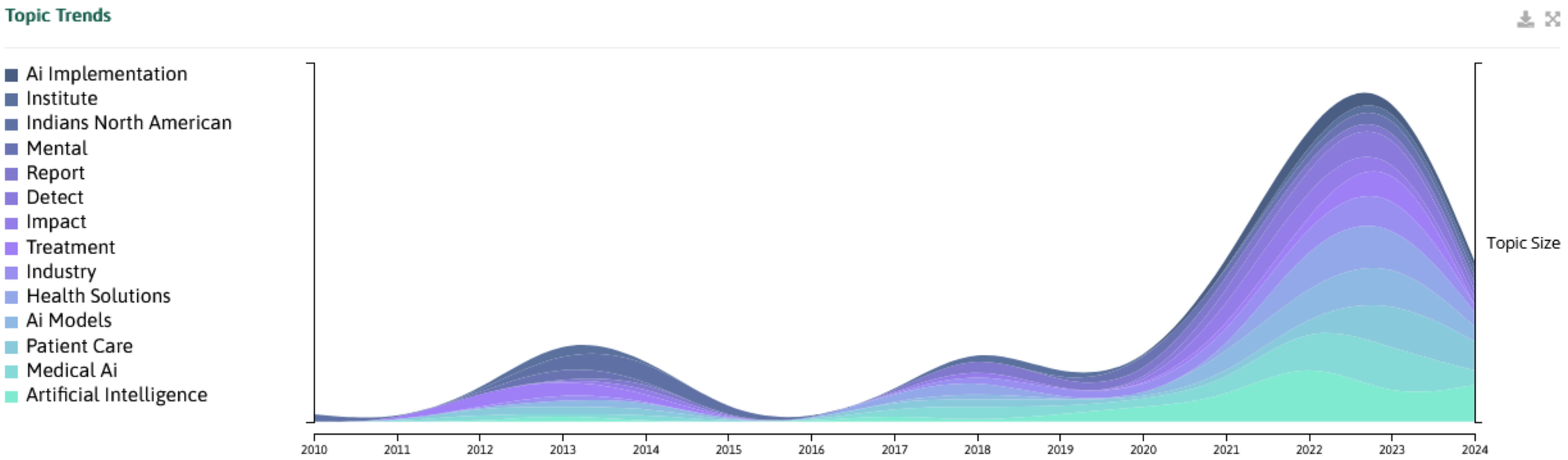
Impact of AI in Medicine

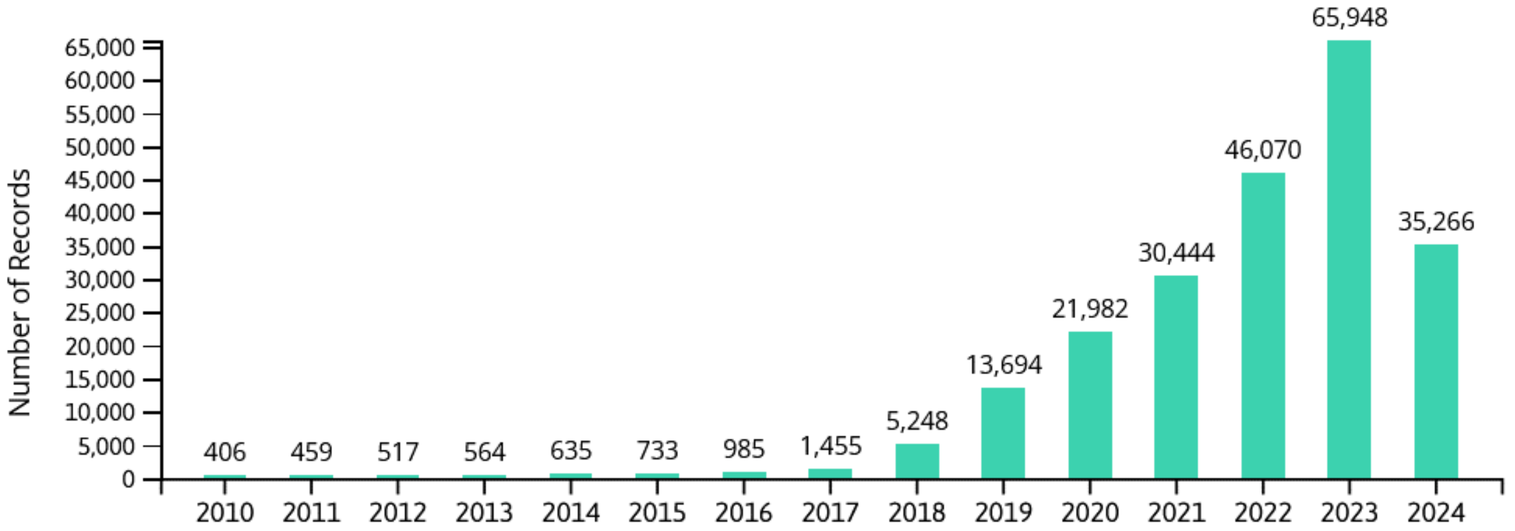
María José Carreira

FEDER
Fondo Europeo de Desenvolvemento Rexional
"Unha maneira de facer Europa"

USC
CAMPUS VIDA
Xacobeo 21·22
UNIÓN EUROPEA
XUNTA DE GALICIA

AI+health Evolution





Graphs from InnoScout tool of Linknovate (May 2024)

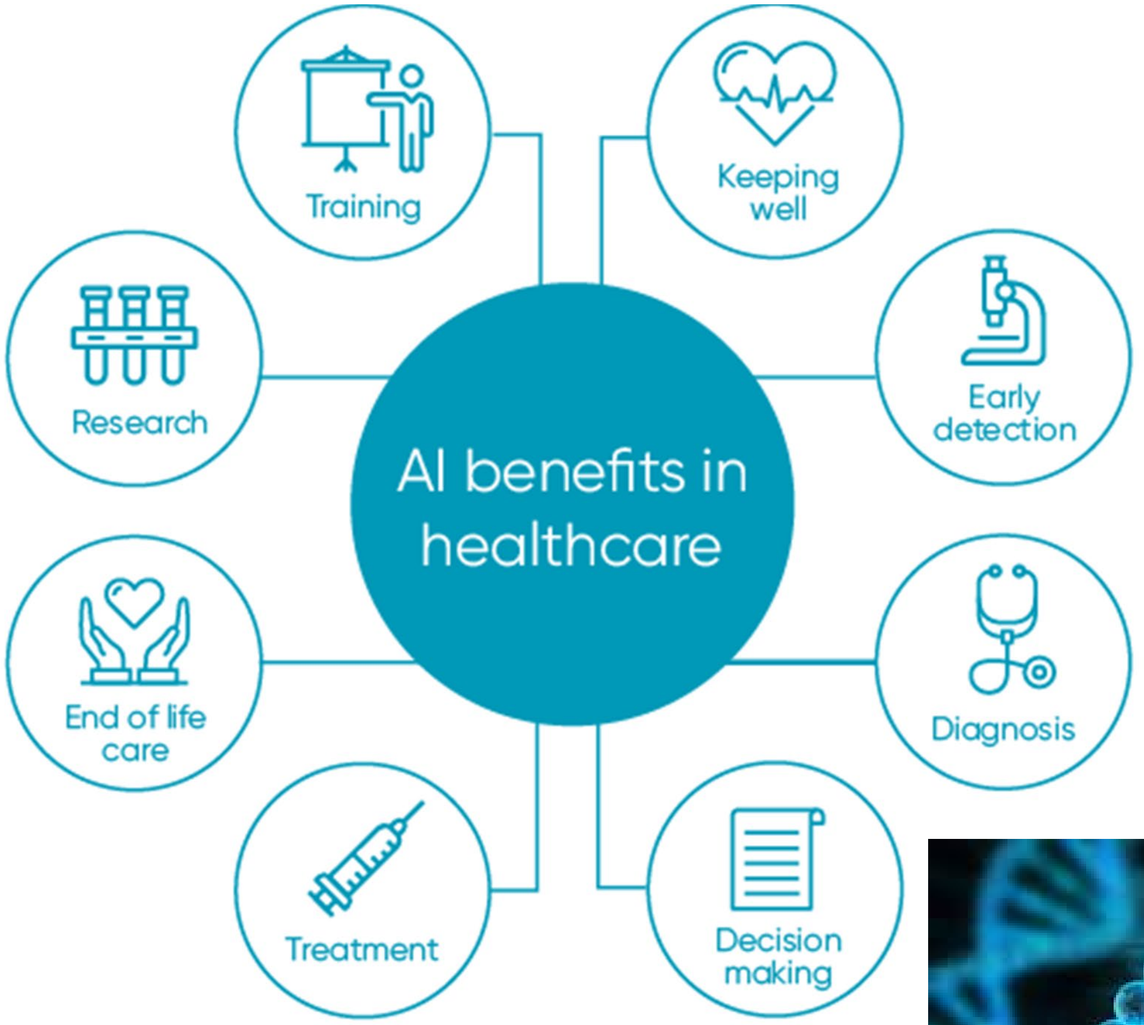
Risks of AI in healthcare

1) **Patient harm due to AI errors**
   - Noisy inputs
   - Data shift between AI training data and real-world data
2) **Misuse of medical AI tools**
   - Poor involvement of physicians and citizens in AI development
   - Lack of training
   - Proliferation of easy-to-use mobile AI solutions
3) **Bias in AI and the perpetuation of existing inequities**
   - Biased datasets: Sex, gender, race, age, socioeconomic status, geographic location, urban or rural context.
   - Lack of diversity in technical, scientific, clinical and policy teams.
4) **Lack of transparency**
   - Traceability and Explainability
   - Lack of trust, difficulties in evaluating AI algorithms, in identifying sources of error, in defining who/what is responsible
5) **Privacy and security issues**
6) **Gaps in accountability**
   - Gaps in national and international regulations. **Responsibility** for errors? **Vulnerability** of healthcare professionals.
7) **Obstacles in implementation**
   - Limited data quality, interoperability, disruption of doctor-patient relationship, lack of integration of AI tools in clinical workflows.

Artificial intelligence in healthcare: applications, risks, and ethical and social impacts. Study. Panel for the Future of Science and Technology, European Parliament Think Tank, June 2022.

Benefits of AI in healthcare

Personalisation in care delivery



Data: images, prescriptions, genetic, mobile health apps

AI in health: medical imaging

Uses of AI in medical imaging

Acquisition

Diagnoses

Treatment

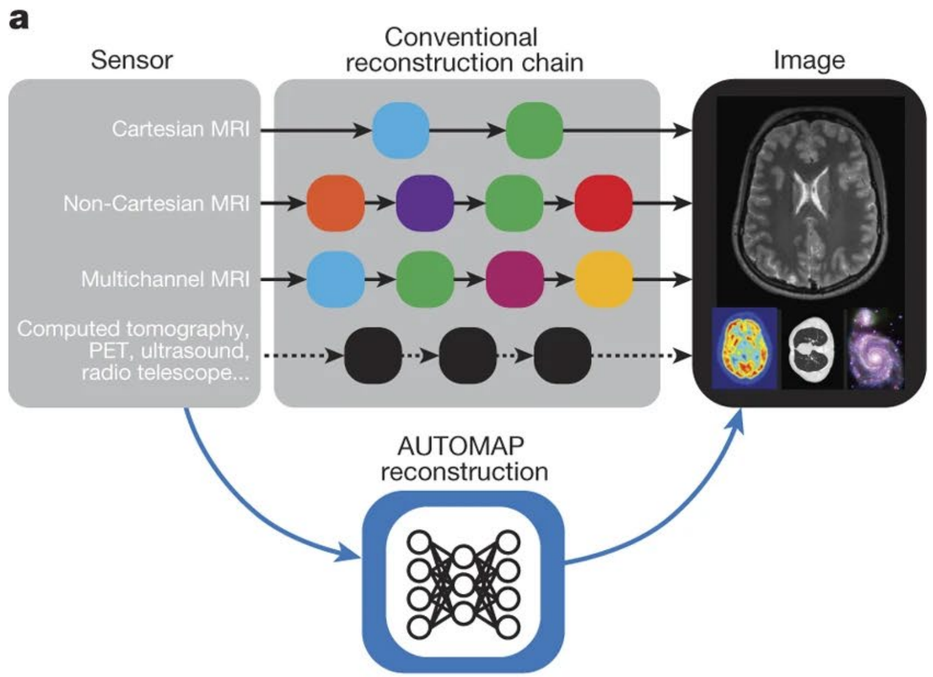
- Reconstruction
- Preprocessing

- Lesion detection
- Region recognition and characterization

- Optimal treatment selection
- Effectiveness evaluation

Some applications using deep learning models

Automatic reconstruction of CT, PET and MRI images using FCN



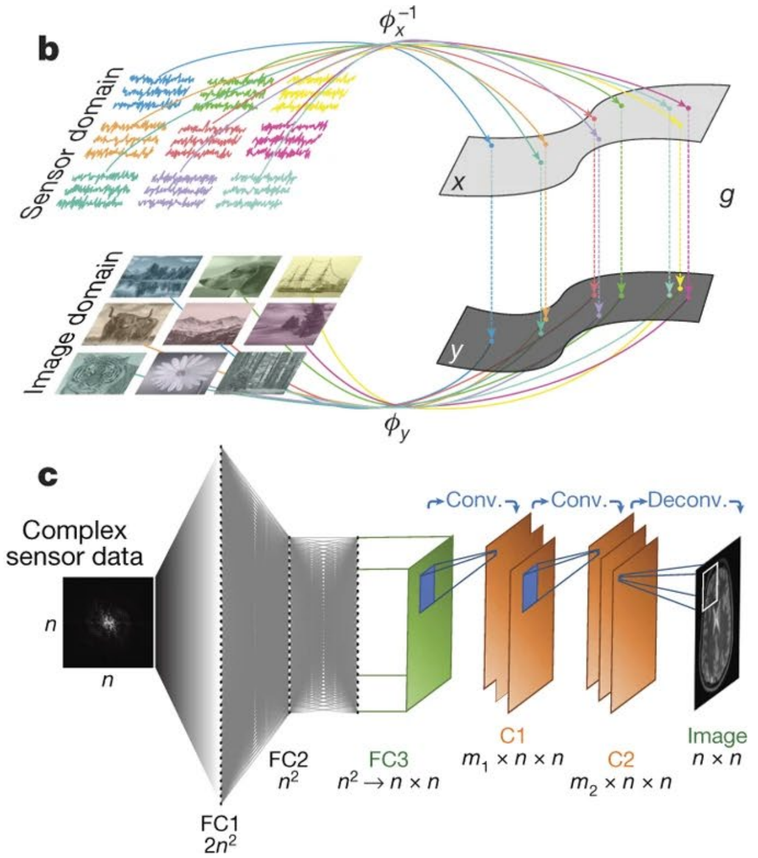
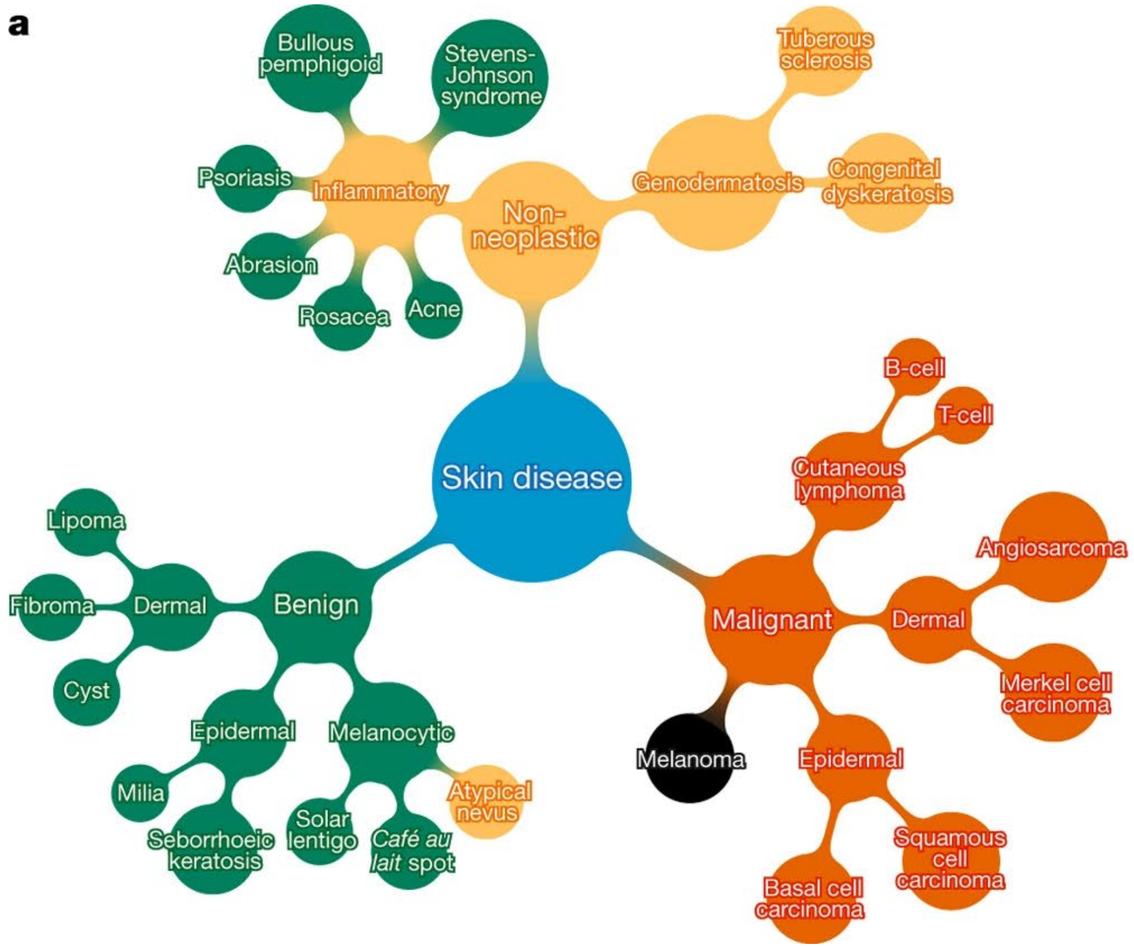
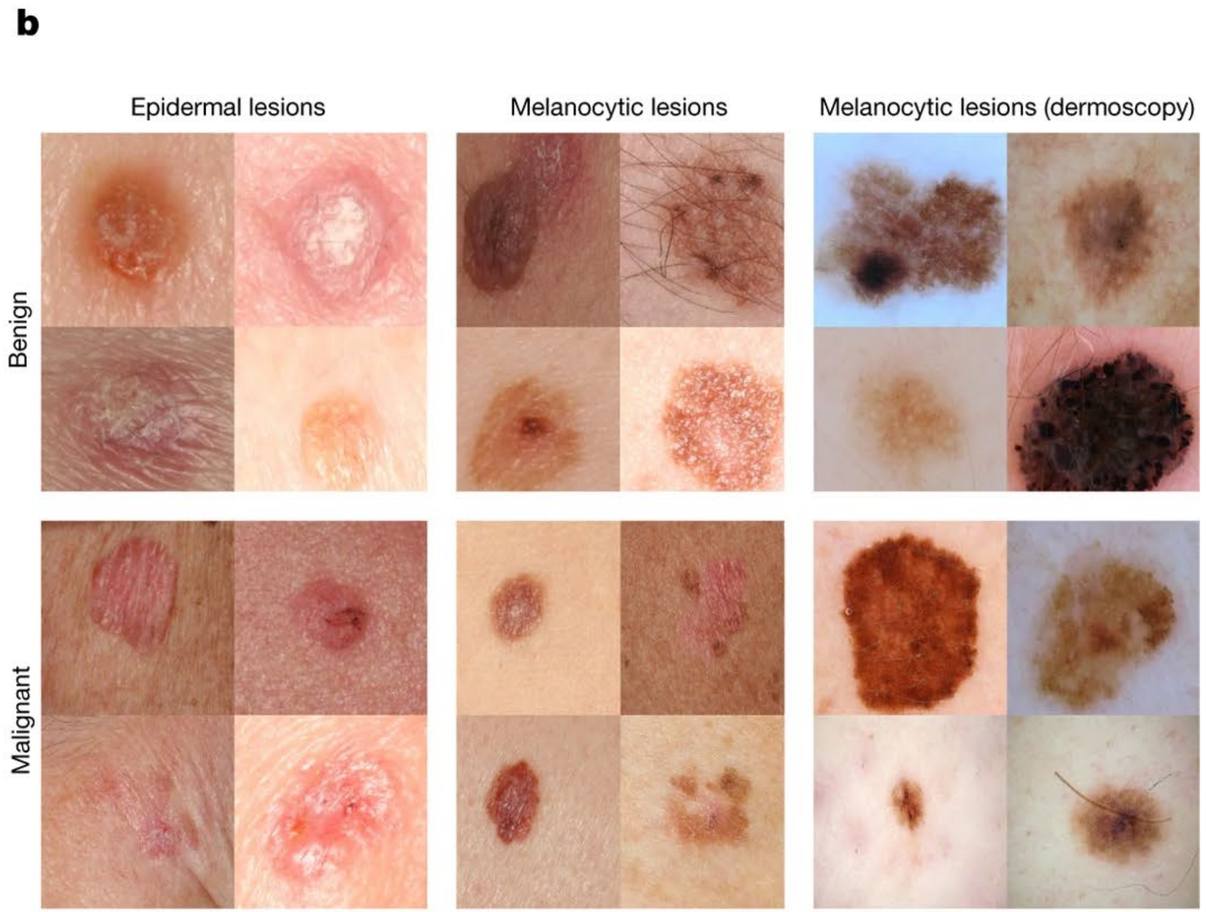


Image reconstruction by domain-transform manifold learning (2018). Nature

Some applications using deep learning models

Detection and categorization of skin cancer using a CNN

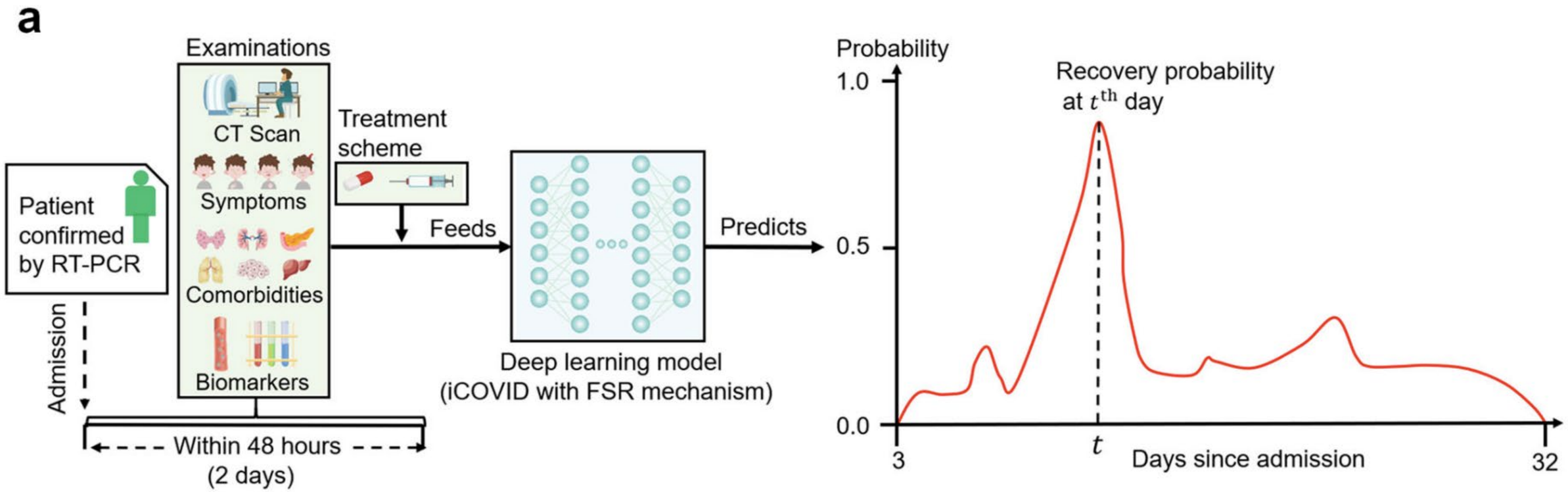




Dermatologist-level classification of skin cancer with deep neural networks (2017). Nature

Some applications using deep learning models

Prediction of **recovery time** in patients with COVID-19 through a CNN



iCOVID: interpretable deep learning framework for early recovery-time prediction of COVID-19 patients (2021). npj Digital Medicine

Segmentation models

Many different approaches:

Intensity-based:
- thresholding (histogram-based)
- clustering

Region growing
Contour based, etc.

} "Classical"

Multi-atlas segmentation (medical imaging)
Deep Learning: U-net (+ 3D-Unet, V-net), nn-Unet, etc.
Foundation models

} ML / AI

Segmentation models

Article | Published: 07 December 2020

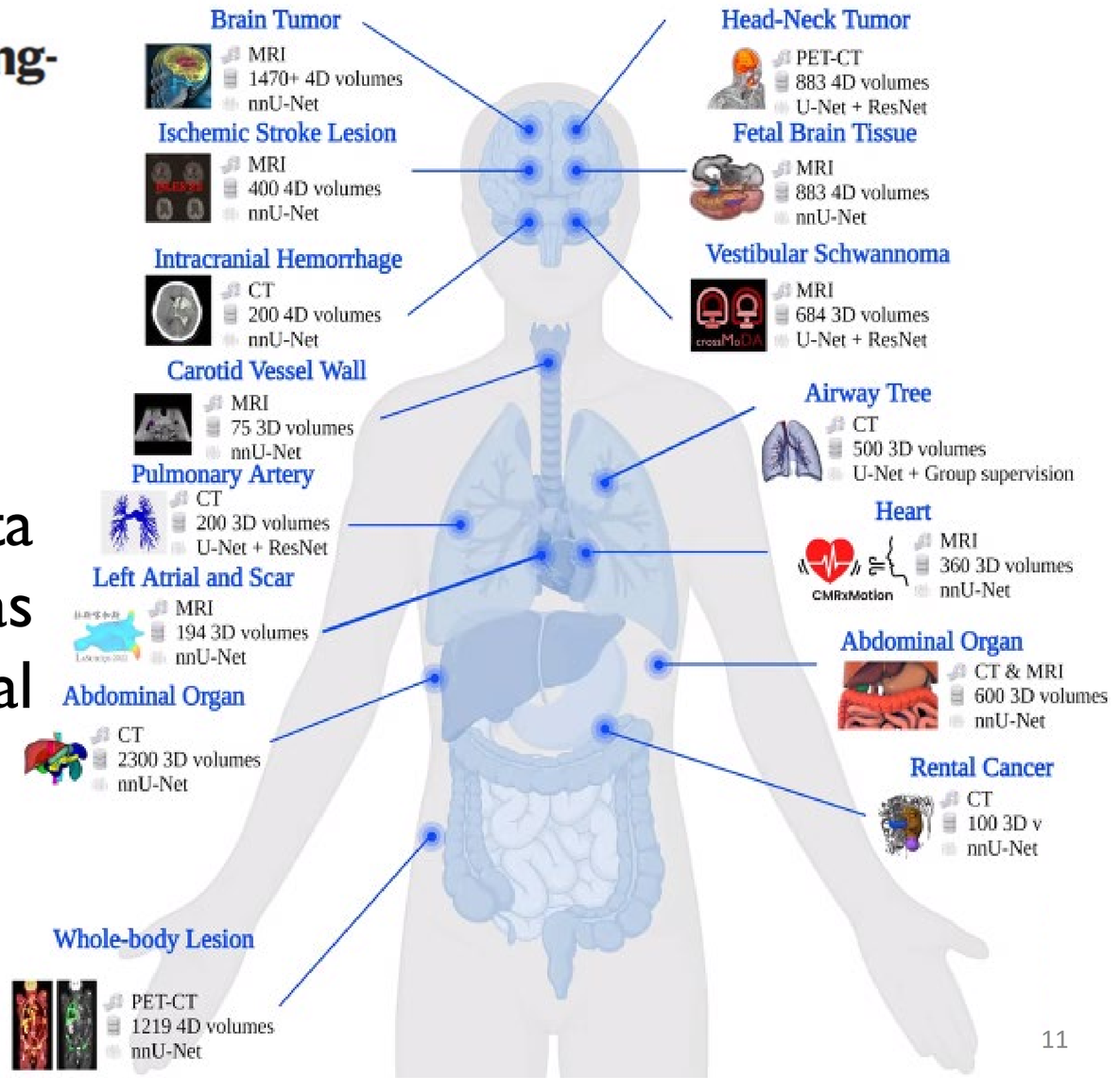
nnU-Net: a self-configuring method for deep learning-based biomedical image segmentation

Fabian Isensee, Paul F. Jaeger, Simon A. A. Kohl, Jens Petersen & Klaus H. Maier-Hein

Nature Methods **18**, 203–211 (2021) | Cite this article

The self-configuring (based on data properties) U-Net, nn-Unet (2021), has become a de facto standard for medical image segmentation

Supervised



Foundation models

Med Image Anal. 2023 Oct:89:102918. doi: 10.1016/j.media.2023.102918. Epub 2023 Aug 2.

Segment anything model for medical image analysis: An experimental study

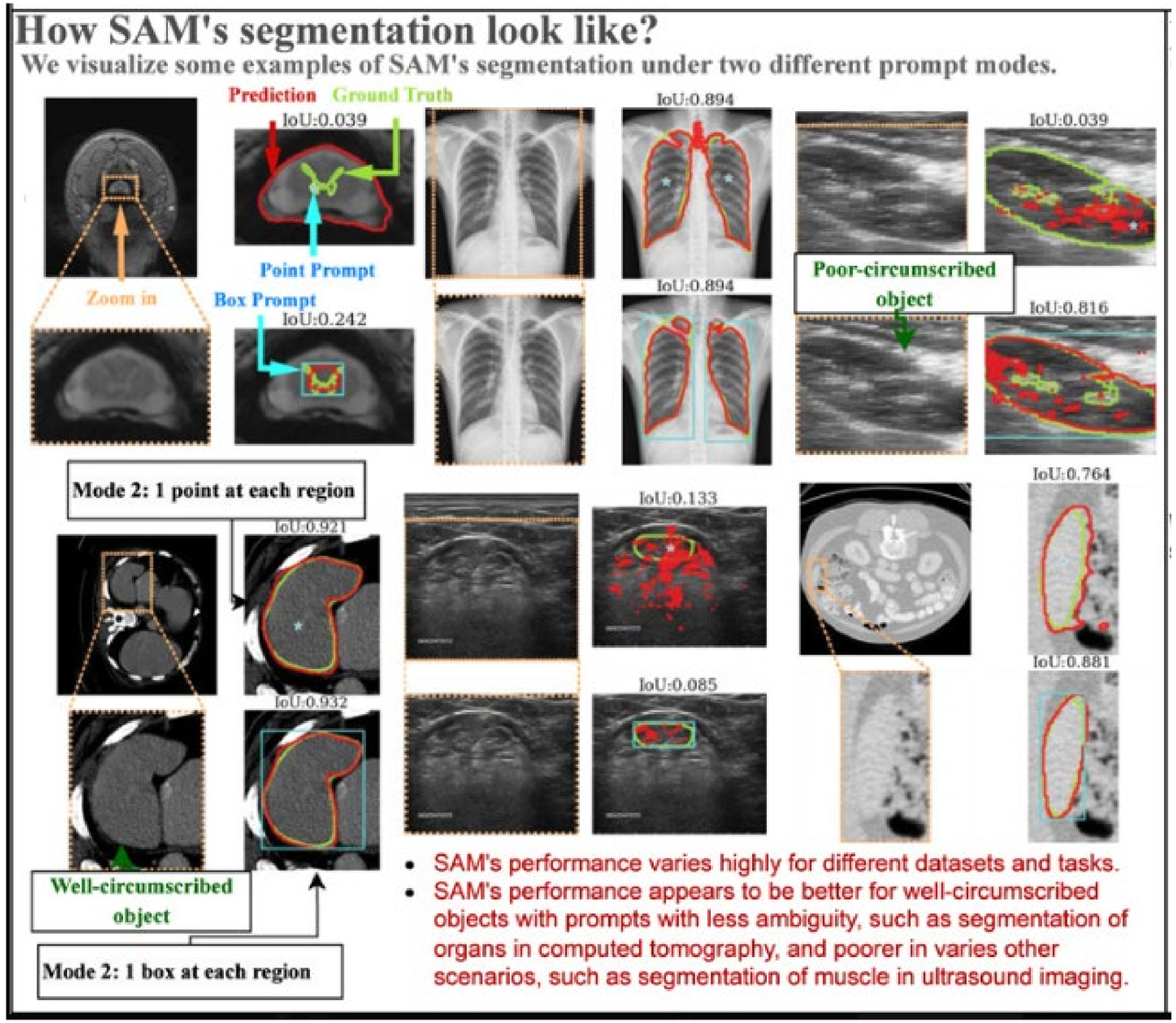
Maciej A Mazurowski [1], Haoyu Dong [2], Hanxue Gu [3], Jichen Yang [3], Nicholas Konz [3], Yixin Zhang [3]

Affiliations + expand

PMID: 37595404 PMCID: PMC10528428 (available on 2024-10-01)
DOI: 10.1016/j.media.2023.102918

11 datasets, various modalities & anatomies

- Impressive performance for certain medical imaging datasets
- Moderate to poor performance for others
- Appropriate care needs to be applied when using it



Foundation models

arXiv > cs > arXiv:2304.06131

Computer Science > Computer Vision and Pattern Recognition

[Submitted on 12 Apr 2023]

UniverSeg: Universal Medical Image Segmentation

Victor Ion Butoi, Jose Javier Gonzalez Ortiz, Tianyu Ma, Mert R. Sabuncu, John Guttag, Adrian V. Dalca

- 42 multi-modal (CT, T1 and T2-weighted MRI, X-ray, ultrasound, etc.) public datasets

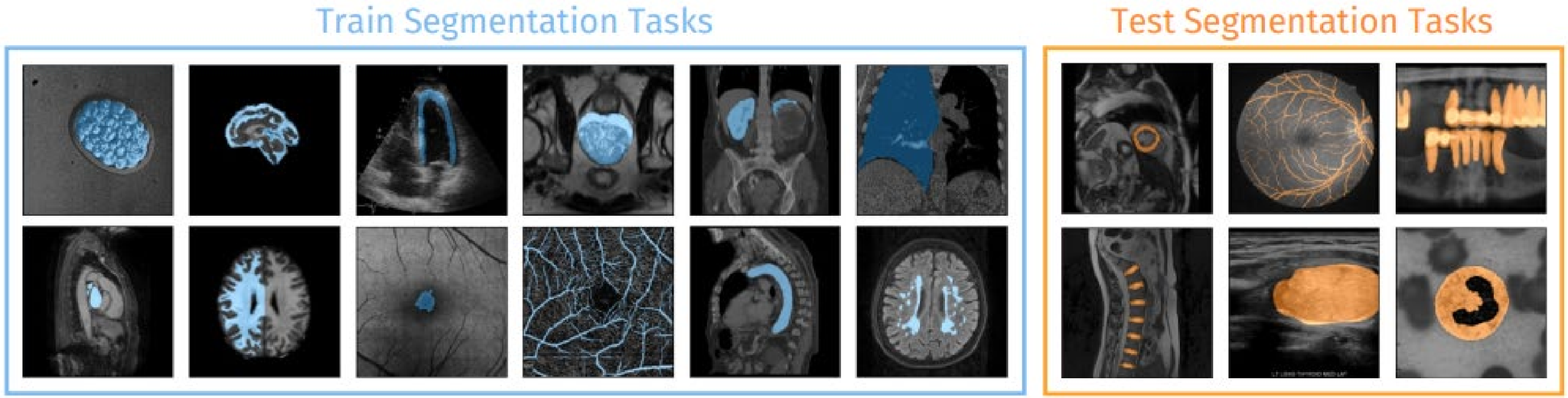
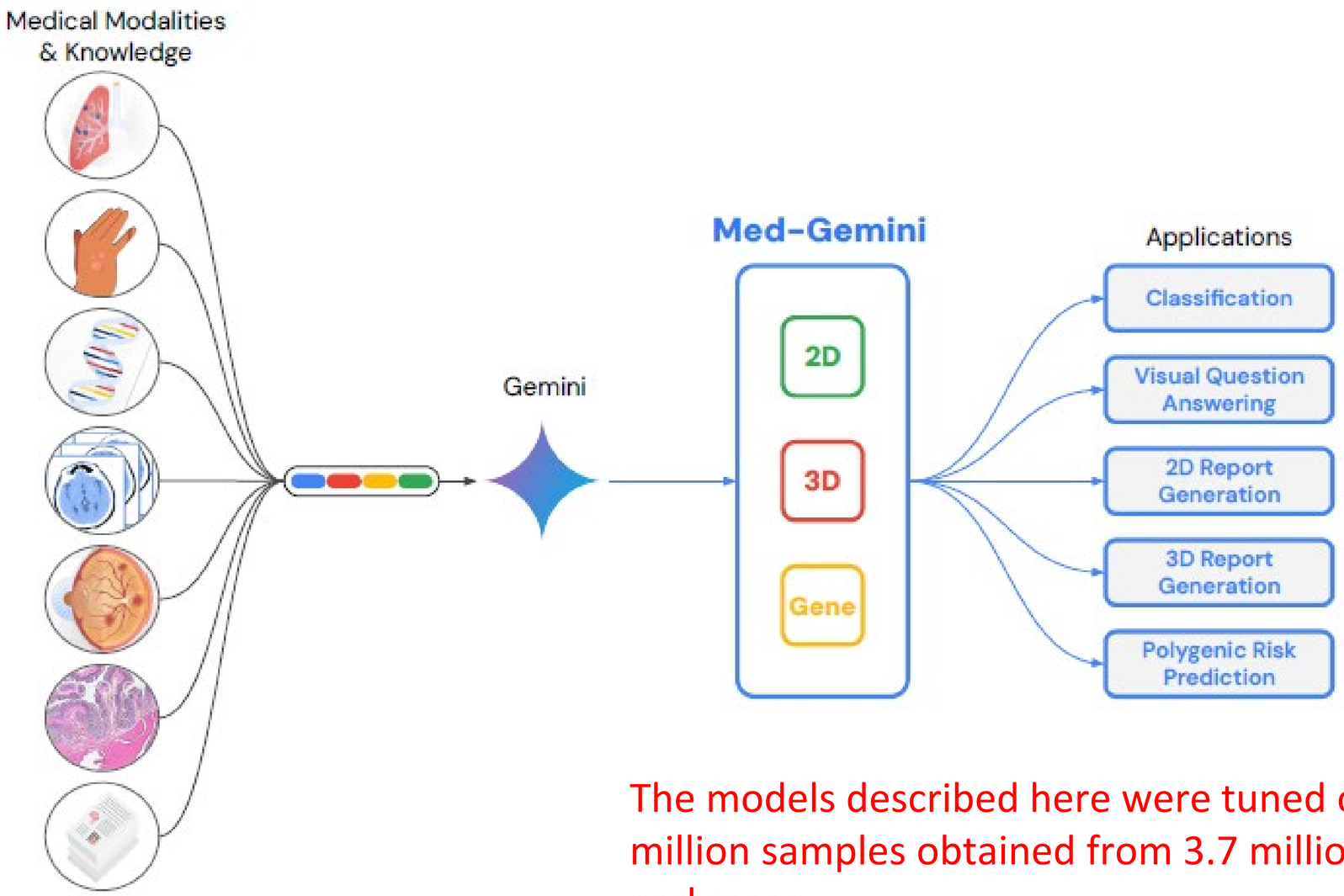


Figure 1: Medical segmentation involves many imaging types, biomedical domains, and target labels. We employ a large diverse set of training tasks **(blue)** to build a model that can segment unseen tasks **(orange)** without additional training.

Med Gemini by Google

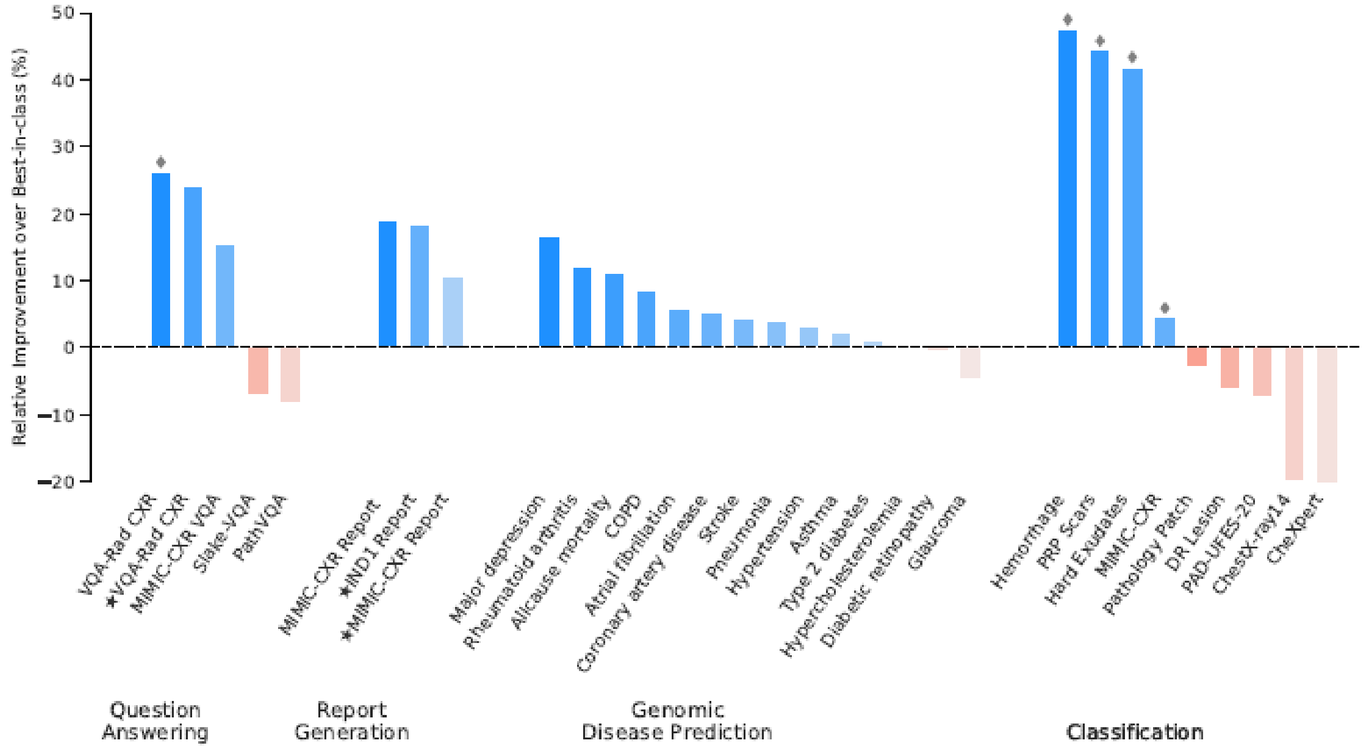


The models described here were tuned on a dataset of 7 million samples obtained from 3.7 million medical images and cases

Advancing multimodal Medical Capabilities of Gemini (2024).

Med Gemini by Google

Advancing multimodal Medical Capabilities of Gemini (2024).



(*) Signifies expert evaluation, while others are assessed using automated metrics such as RadGraph-F1, Accuracy, AUC, and F1 scores.
(♦) Indicates comparison with Gemini where best-in-class performance is not available.

Table A.15 | Overall Performance Summary of Med-Gemini This table represent the aggregated results comparing Med-Gemini to the previous state-of-the-art (SoTA), Gemini or strong baseline where available.

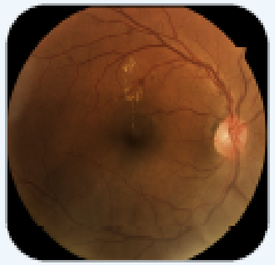
Capabilities	Datasets	Metric	Med-Gemini	Gemini	Baseline or SoTA	Reference
Report Generation	MIMIC-CXR	RadGraph	24.4	N/A	20.5	Tanno et al. (2024)
	MIMIC-CXR	Expert (AI superior)	47.6	N/A	43.0	Tanno et al. (2024)
	IND1	Expert (AI superior)	75.4	N/A	63.7	Tanno et al. (2024)
VQA	MIMIC-CXR VQA	Accuracy	78.6	70.9	68.1	Xu et al. (2023)
	Slake-VQA	Accuracy	84.8	70.4	91.1	Li et al. (2023b)
	VQA-Rad CXR	Expert	71.9	N/A	57.9	Xu et al. (2023)
	VQA-Rad CXR	Accuracy	78.8	62.4	N/A	N/A
	PathVQA	Accuracy	83.3	62.8	90.9	Sun et al. (2024)
Genomic Disease Prediction	Coronary artery disease	AUC	82.5	N/A	78.5	Ensemble of PRSs and Demographics
	Stroke	AUC	78.1	N/A	74.8	
	Type 2 diabetes	AUC	86.5	N/A	85.5	
	Glaucoma	AUC	78.9	N/A	82.8	
	COPD	AUC	83.9	N/A	77.4	
	Rheumatoid arthritis	AUC	79.2	N/A	70.6	
	Major depression	AUC	70.2	N/A	60.2	
	Allcause mortality	AUC	79.9	N/A	71.8	
	Hypertension	AUC	72.0	N/A	69.9	
	Hypercholesterolemia	AUC	52.4	N/A	52.1	
	Atrial fibrillation	AUC	78.7	N/A	74.4	
	Diabetic retinopathy	AUC	87.0	N/A	87.5	
	Pneumonia	AUC	71.6	N/A	68.9	
	Asthma	AUC	57.7	N/A	56.5	
Classification	Hard Exudates	F1	87.3	61.5	N/A	N/A
	Hemorrhage	F1	85.3	57.8	N/A	N/A
	PRP Scars	F1	82.3	57.0	N/A	N/A
	DR Lesion	F1	86.4	63.9	92.0	Krause et al. (2018)
	PAD-UFES-20	F1	71.4	60.3	70.0	Google (2024)
	MIMIC-CXR	F1	90.7	86.8	N/A	N/A
	CheXpert	F1	48.3	42.6	60.6	Tiu et al. (2022)
	ChestX-ray14	F1	46.7	34.2	58.3	Majkowska et al. (2020)
	Pathology Patch	AUC	89.2	88.4	91.7	Sun et al. (2024)

Med Gemini by Google

*Examples of **2D medical image dialogue** via open ended question answering: fundus image, skin lesion image, histopathology*

Prompt

What are the findings?



Response

Hard exudates is present. Hemorrhage is present.

Prompt

Does the patient have DR? If yes, what is the severity level?

Response

Yes, moderate

Prompt

How to treat it?

Response

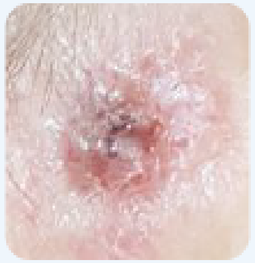
Laser photocoagulation

Clinician Review

Missed microaneurysms in the findings. DR severity is correct. Treatment should include Intravitreal anti-VEGF injection.

Prompt

Describe the image below.



Response

The image shows a red, raised, and round skin lesion. The most common cause of this condition is basal cell carcinoma.

Prompt

What is the treatment of this carcinoma?

Response

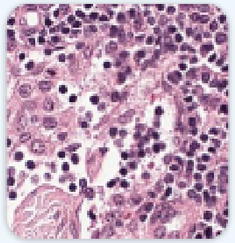
Basal cell carcinoma is a type of skin cancer that is usually treated with surgery. The type of surgery used will depend on the size and location of the tumor.

Clinician Review

Need to change "the most common cause" to "a common cause" and "treated with surgery" to "treated with surgical removal".

Prompt

Tell me about this histopathology image.



Response

H&E stained section of a lymph node demonstrating the mix of small, mature lymphocytes and occasional larger immune cells.

Prompt

Is there any tumor in this image?

Response

No.

Prompt

What are the slightly larger cells in the middle left part of the image?

Response

These are likely immune cells called plasma cells, which are a normal part of the immune system.

Patch-level Ground Truth

Lymph node, non-tumor

Expert Review

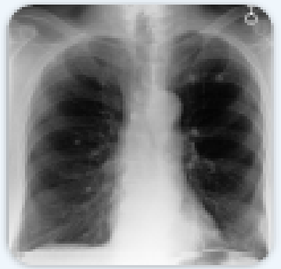
Aligns with the ground truth, although perhaps challenging to be sure this is from lymph node without additional context.

Med Gemini by Google

*Example of chest X-ray report **generation***

Prompt

Given the following chest X-ray, describe the FINDINGS and IMPRESSION in the image.



Response

FINDINGS: The lungs are hyperinflated with flattening of the diaphragms and increased ap diameter, suggesting chronic obstructive pulmonary disease. No focal consolidation, pleural effusion, or pneumothorax is detected. Heart and mediastinal contours are within normal limits with extensive aortic calcification. IMPRESSION: no acute cardiopulmonary process.

Chronic abnormality with hallucination, as "increased ap diameter" is usually detected from a lateral image

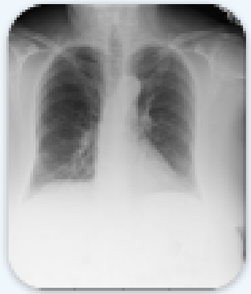
Radiologist Written Report

FINDINGS: Frontal and lateral views of the chest were obtained. The lungs are hyperinflated, with flattening of the diaphragms, consistent with chronic obstructive pulmonary disease. There is mild left basilar atelectasis. No focal consolidation is seen. There is no pleural effusion or pneumothorax. The cardiac and mediastinal silhouettes are unremarkable. Degenerative changes are seen along the spine. IMPRESSION: COPD and left basilar atelectasis. Otherwise, no acute cardiopulmonary process.

*Example of chest X-ray report **autocompletion***

Prompt

Given the following chest X-ray, describe the FINDINGS and IMPRESSION in the image.



Response

FINDINGS: the lungs are clear without focal consolidation, effusion, or edema. cardiomediastinal silhouette is stable. tortuosity of the descending thoracic aorta is again noted. no acute osseous abnormalities. IMPRESSION: no acute cardiopulmonary process.

Comparison with Radiologist's Notes (not shown):

Missing concepts of emphysema on the lung.

Response Hint

FINDINGS: Hyperlucency of the upper zones...

Auto-completed Response

...of the lungs is consistent with **emphysema**.

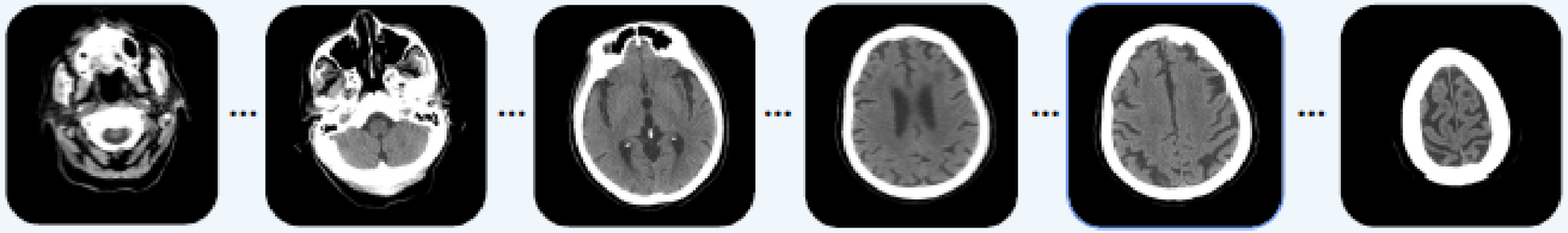
Particular concept was missing from the report generated without any hint and were recovered with the autocomplete prefix hint.

Med Gemini by Google

*Example of **3D Head CT report generation** (abnormalities missed by radiologist in green, but sometimes hallucinate findings absent from the image).*

Prompt

Given the image, what are the radiology findings?



Response

FINDINGS: mild cortical atrophy and periventricular white matter changes are noted compatible with microvasculopathy. there is proportionate ventriculomegaly. no bleed, mass effect, midline shift or abnormal intracranial fluid is seen. no evidence of acute intracranial hemorrhage, territorial infarct, abnormal fluid or mass effect.no abnormal extra-axial fluid collection is identified. no definitive evidence of intracranial hemorrhage or large territorial infarct within the limits of ct imaging. old left basilar ganglia infarct. no intracranial mass, swelling, hemorrhage, infarction or extra-axial collection is seen. visualized mastoid air cells: well pneumatized. visualized paranasal sinuses: well pneumatized. atherosclerotic calcification of vasculature at the skull base.

Radiologist Written Report

FINDINGS: the fourth ventricle is midline. the remaining ventricular system is within normal limits. there is mild chronic white matter microangiopathic disease and moderate generalized cortical atrophy. no bleed, mass effect, midline shift or abnormal intracranial fluid is seen. bone windows demonstrate an intact skull. the remaining visualized paranasal sinuses and mastoids are clear. chronic white matter microangiopathic disease, mild generalized cortical atrophy, not significantly changed since 2015. no evidence of acute intracranial hemorrhage, territorial infarct, abnormal fluid or mass effect.

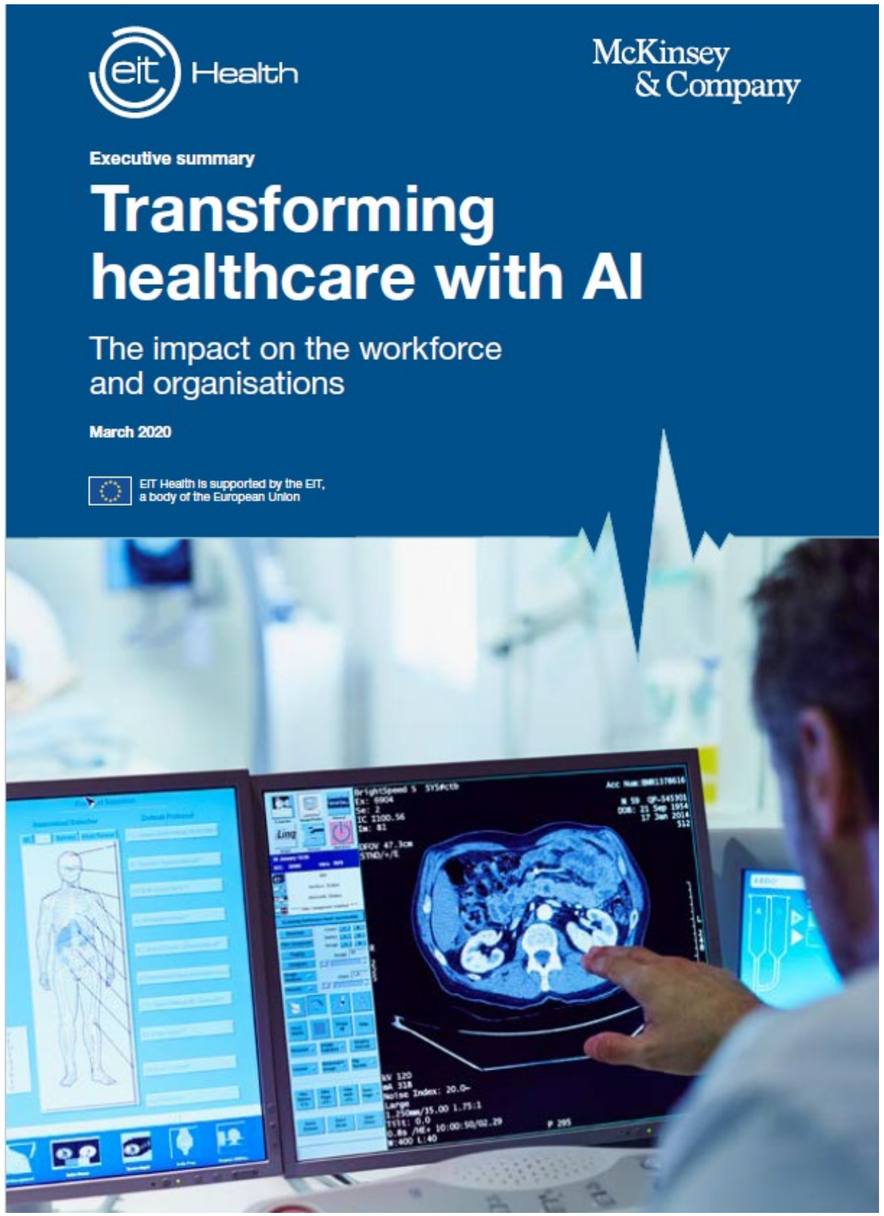
Med Gemini by Google

Conclusions: Areas in which future evaluations should focus before models like these are considered safe and effective for clinical use:

- **Closing the gap between benchmark and bedside**
  - Limitations of benchmarks in **size**, **scope**, and reflection of **real-world distributions**
  - Potential for **generative AI in assisting**, rather than replacing human specialists
  - **Evaluations** should shift from static benchmarks to **realistic clinical scenarios** that assess AI-human collaboration and its **impact on patient outcomes**
- **Identifying and mitigating data bias and safety risks**
  - Inherit biases from source data → **misdiagnoses** and **amplification of systemic bias**
  - Discover and mitigate **risks**
  - **Validate** model performance for specific use cases and patient populations
- **Minimizing data contamination when evaluating zero-shot generalization in large models**
  - Massive training datasets increase the potential for data contamination, which may result in **overestimation** of their true generalization capabilities.

AI in health systems

Study of the impact of AI in health (2020)



- *Financed by European Union with enquiries to principal actors: healthcare professionals, managers and counsellors of emergent companies.*

Study of the impact of AI in health (2020)

AI will not replace healthcare professionals but will enhance their ability to influence in patients and healthcare systems.

HCPs can refocus energy on patients, spending less time on administrative tasks and more on direct delivery of care

Activities that currently occupy between 20 to 80% of doctor and nurse time can be streamlined or even eliminated by using AI.

Some activities will be more efficient or deliver better outcomes (or both)

For example, a diagnostic tool could be powered by AI to identify eye disease with the same accuracy as expert clinicians. This could reduce the time to diagnosis allowing providers to treat patients or refer them to the right specialists for further treatment more quickly.

As intelligent machines take over more physical, repetitive and basic cognitive tasks, social and emotional skills will become more essential

These will be vital in helping to coach patients on the use of AI solutions and monitoring their impact. This will be particularly useful for patients with chronic conditions who may be managing their disease with AI-enabled monitoring and decision support.

The average patient coming to hospital may have more complex needs

AI applications will enable more patients with mild to moderate conditions to have home-based care, meaning HCPs can focus their time on patients with more complex needs. Futhermore, HCPs will need to know how best to use AI clinical decision support to navigate the growing quantity of information on treatments. They will need to change their approach to education, seeing lifelong learning, and digital and AI literacy as cornerstones of their practice.

New professionals will need to be welcomed and integrated into healthcare

AI engineers and data scientists will be intrinsic parts of healthcare delivery. There will be an urgent need for healthcare organisations to attract and retain such valuable and in demand talent, by developing flexible and exciting career paths and clear routes to leadership roles.

What needs to change to support the adoption and scaling of AI in healthcare? (i)

#1

Work together to deliver quality AI in healthcare

A lack of multidisciplinary development and early involvement of HCPs, and limited iteration by joint AI and healthcare teams, were cited as major barriers to addressing quality issues early and adopting solutions at scale.

#2

Rethink education and skills

Leaders will need to be well-versed in both biomedical and data science. Skills such as basic digital literacy, basic genomics, AI and machine learning must become mainstream for all HCPs, supplemented by critical thinking skills and development of a continuous-learning mindset.

#3

Strengthen data quality, governance, security and interoperability

Data access, quality and availability were potential roadblocks cited by all. In addition, as more healthcare is delivered using new digital technologies, public concerns about how healthcare data are used have increased.

Healthcare organisations should have robust and compliant data-sharing policies that support the improvements in care that AI offers while providing the right safeguards in a cost-efficient way.

#4

Manage change

Clinical leadership is key, as is being open to identifying the right use cases that support rather than antagonise HCPs and truly augment rather than substitute their ability to deliver the best possible care to their patients.

This could include prioritising solutions that focus on reducing the time people spend on routine administrative tasks, rather than those that seek to act as virtual assistants who interact directly with patients.

What needs to change to support the adoption and scaling of AI in healthcare? (ii)

#5

Invest in new talent and creating new roles

Develop and recruit the new roles that will be critical to the successful introduction and adoption of AI, such as data scientists or data engineers.

Demand for such skills is heating up across industries and the competition for talent will be fierce.

Developing flexible, agile models to attract and retain such talent should be an essential part of people strategies.

#6

Work at scale

Not every hospital will be able to afford to attract new AI talent, or have access to enough data to make algorithms meaningful.

Smaller organisations can benefit from working in innovation clusters that bring together AI, digital health, biomedical research, translational research or other relevant fields.

Larger organisations can develop into centres of excellence that pave the way for regional and public-private collaborations to scale AI in European healthcare.

#7

Regulation, policy making and liability, and managing risk

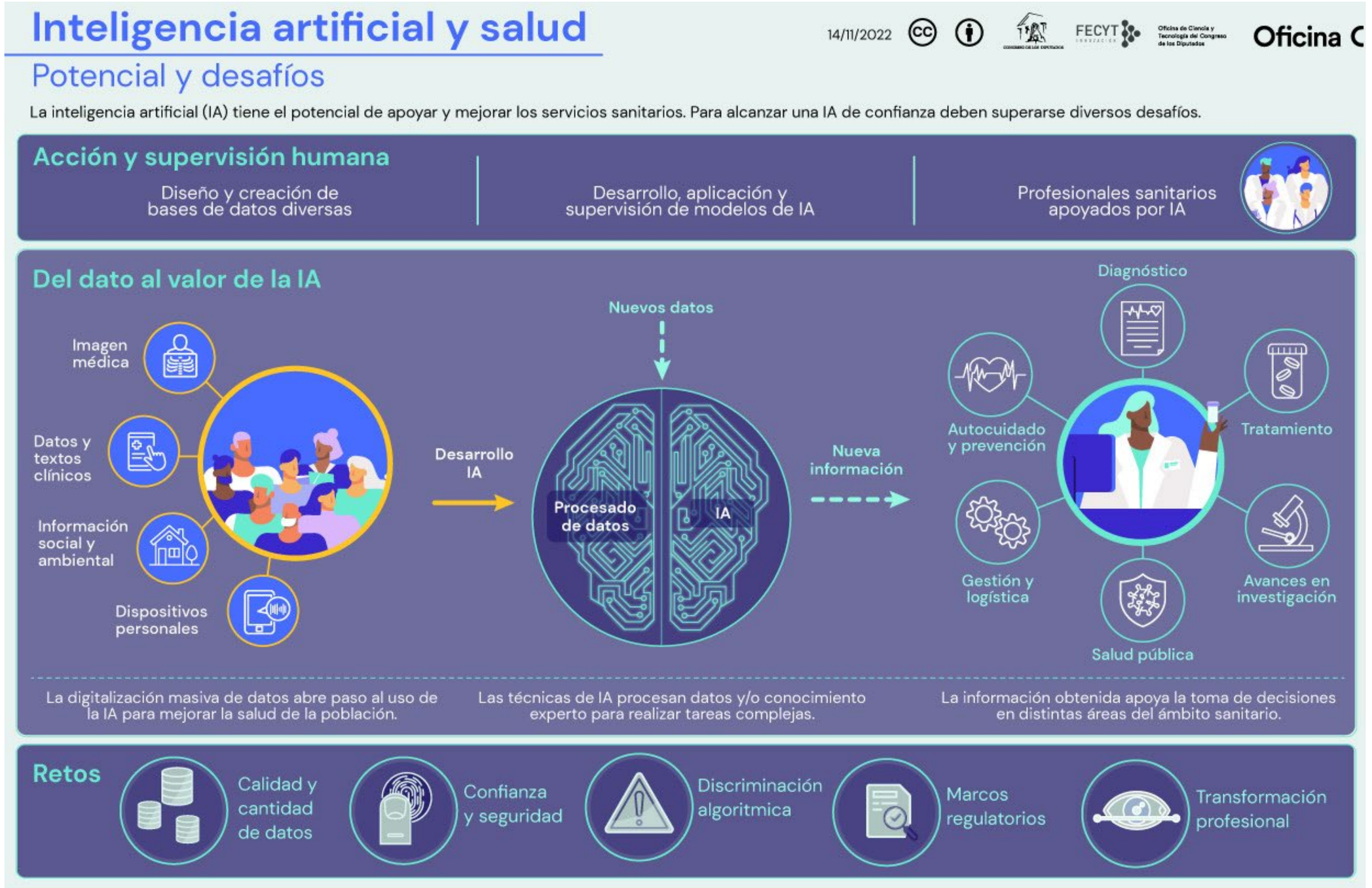
There is a need to clarify whether AI will be regulated as a product or as a tool that supports decision making, and for a consistent regulatory approach similar to that provided by the European Medicines Agency (EMA) on medicines or by national authorities on medical devices.

#8

Funding

Clear criteria for the potential reimbursement of AI applications will be crucial for its adoption at scale, alongside creative funding models that ensure the benefits are shared across organisations.

AI in Health: Report by the Office of Science and Technology of the Spanish Congress (November 2022)



Centro Singular de Investigación en Tecnoloxías Intelixentes

Impact of IA in Medicine

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