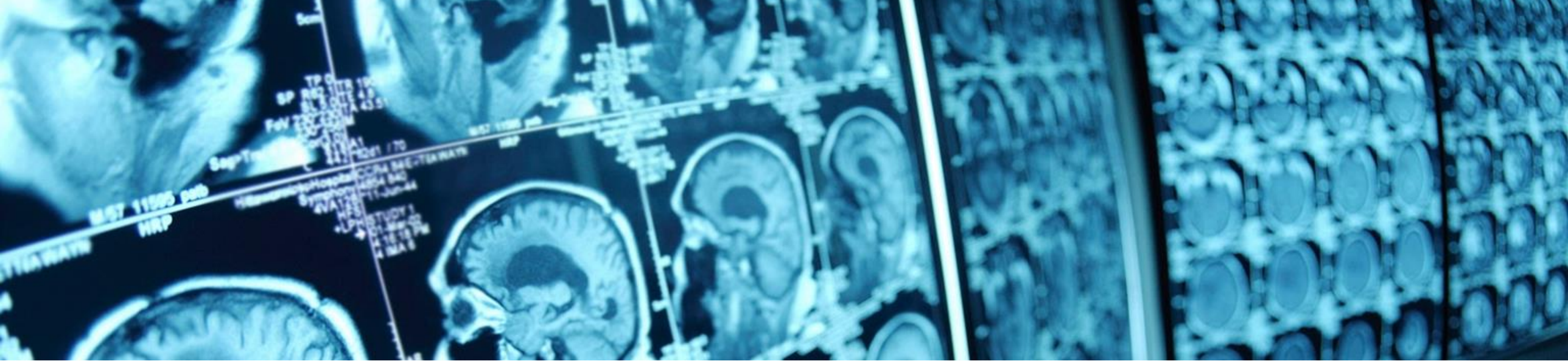
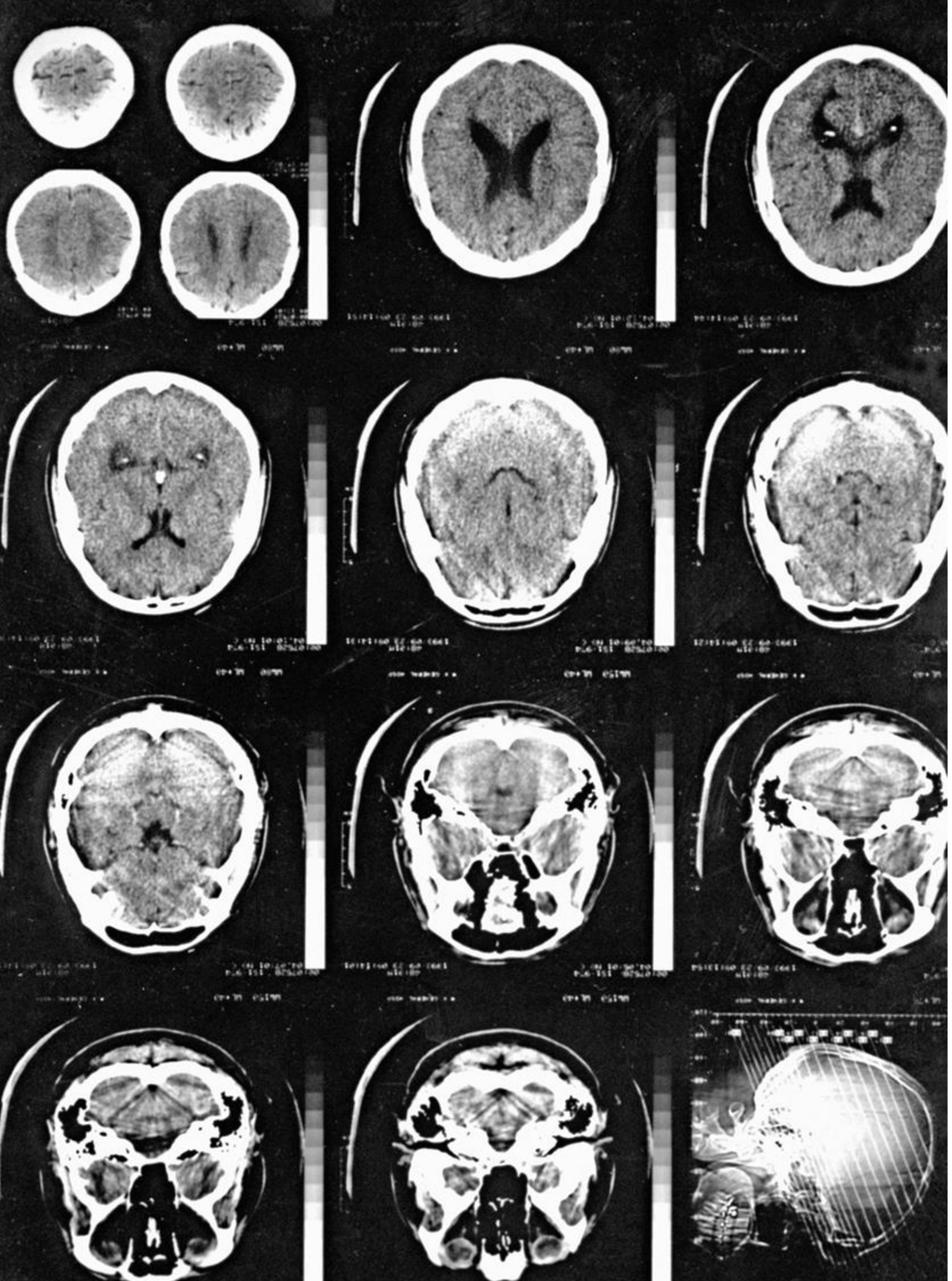


C4- AI in Neuroimaging for Pediatrics



Thesis

- Artificial intelligence (AI) is emerging as a valuable tool in the diagnosis of neurologic pathologies in the pediatric population.

Objectives

- Evaluate the effectiveness of AI assisting in treatment and diagnosis of neurological pathologies in pediatric patients.
- Discuss studies on AI's accuracy in reducing scan times, exposure, read time, and improving patient outcomes.
- Compare the benefits and limitations of using AI for neuroimaging in pediatrics.
- Summarize findings and future research on neuroimaging in pediatrics.

Importance of Neuroimaging in Pediatrics

- The developing pediatric brain has unique characteristics that require specialized imaging and different approaches to ensure accurate detection, diagnosis, and treatment (Dalboni da Rocha et al., 2025).

- About 0.5-1% of children globally are affected by pediatric epilepsy, which can disrupt healthy brain development and have significant impacts on quality of life (Guarnera et al., 2025).

Importance of Neuroimaging in Pediatrics

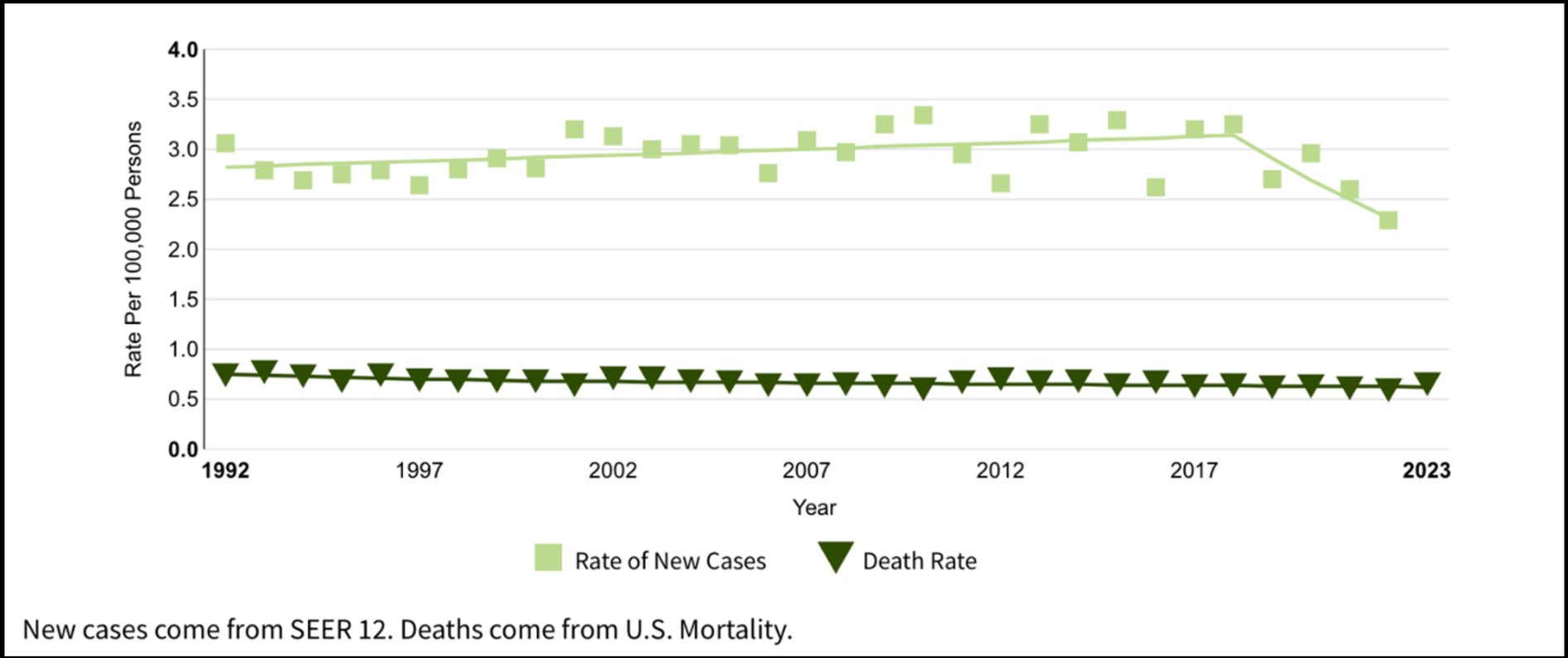
- Cancers and brain tumors in pediatric patients are some of the leading causes of death in children.

- In 2025, about 9,550 children from birth to 14 years old will be diagnosed with cancer and of those, 1,050 are not expected to survive.

- Among children ages 0-14, the cancers most often diagnosed are tumors of the brain and central nervous system, leukemias, and lymphomas.

(National Cancer Institute, 2025)

Childhood Brain and Other Nervous System Cancer Rates



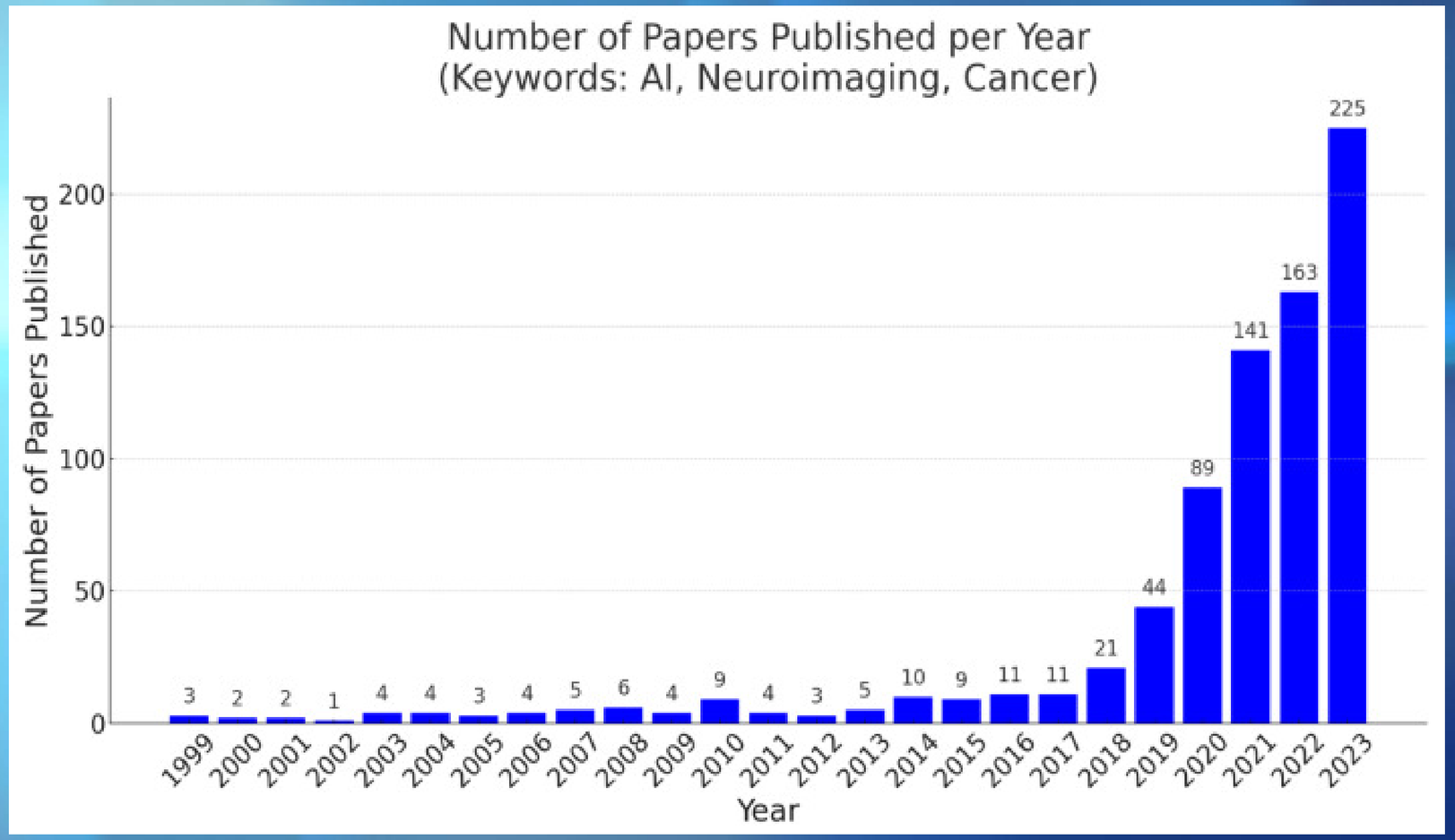
"Childhood Cancer of the Brain and Other Nervous System - Cancer Stat Facts." SEER, seer.cancer.gov/statfacts/html/childbrain.html

This chart is showing the rate of new cases along with the death rate among childhood brain and nervous system cancers. About 15.1% of all new childhood cancer cases are brain and or other nervous system cancers (SEER).

What is AI?

Artificial intelligence (AI) refers to computers performing tasks to mimic human intelligence like learning, problem solving, and decision making. AI's growing abilities can greatly improve how efficiently and effectively medical images are used.

(Gore, 2020)



AI in neuroimaging research has significantly increased over the years.

Dalbondi da Rocha et al., (2025) Fig. 2 Number of papers published per year containing the keywords “artificial intelligence’, “neuroimaging”, and “cancer”, according to the ScienceDirect search tool. [Graph]. Cancers. https://pubmed.ncbi.nlm.nih.gov/40002217/#&gid=article-figures&pid=figure-2-uid-1

AI vs. Neuroradiologists

- Increased workloads can create strain on the radiologists and affect their ability to read images accurately.
  - This strain leads to a higher likelihood of errors that AI could detect using advanced algorithms (Gore, 2020).
- With more powerful computers AI has made it easier to analyze medical images by taking advantage of the increasing amount of medical data available (Huang, et al., 2022).
  - Out of six studies comparing AI to experts, five of them resulted with AI detecting tumors better (Huang et al., 2022).
  - AI can be helpful in neuroradiology for problems like brain birth defects, epilepsy, brain tumors, genetic or metabolic disorders, brain injuries, and damage from lack of oxygen at birth (Guarnera et al., 2025).

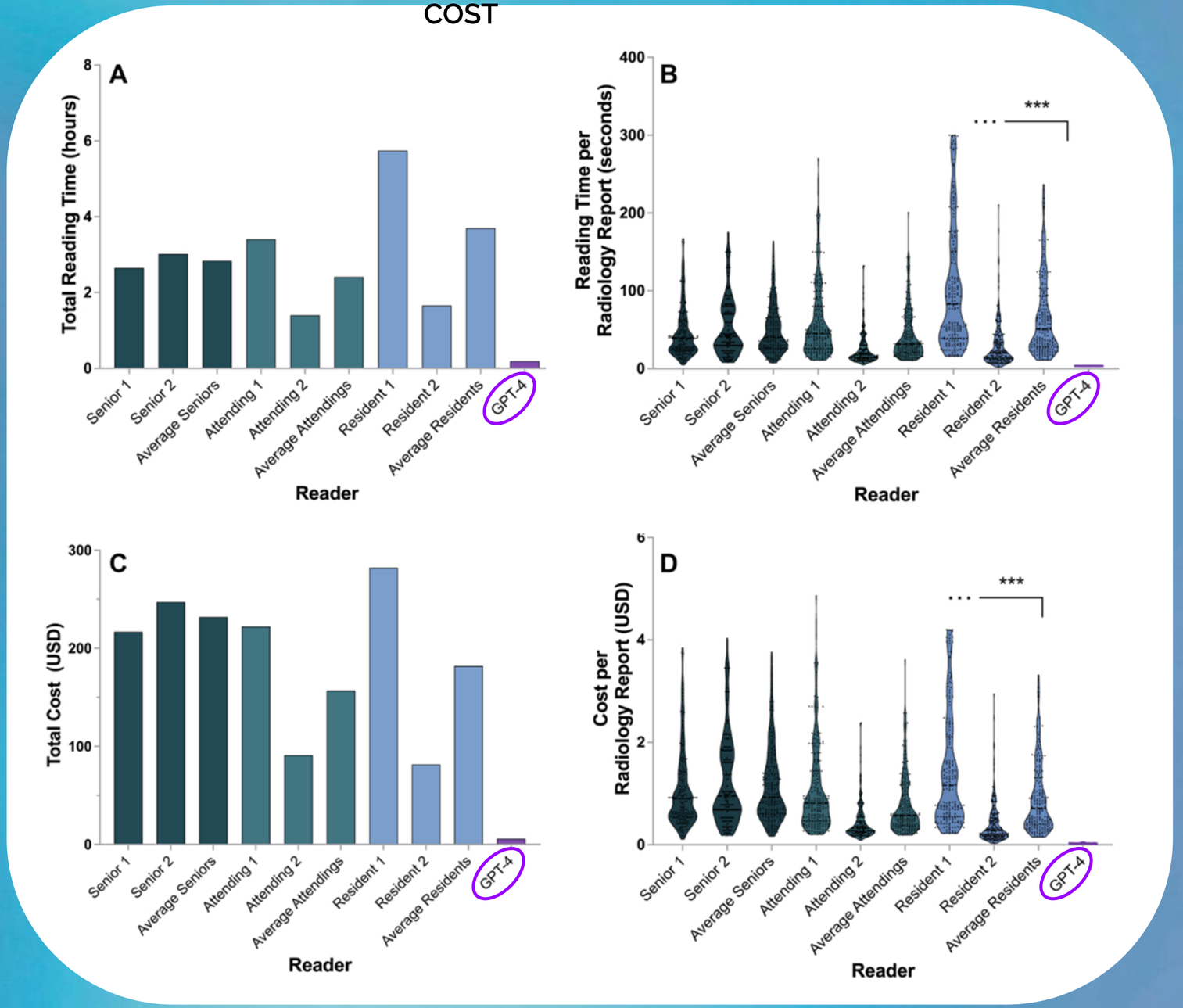
AI vs. Neuroradiologists

- Researchers tested the AI program Generative Pre-Trained Transformer 4 (GPT-4) and compared it to 6 human radiologists with a range of different experiences.
- It was found that GPT-4's performance in spotting errors was comparable to the non-senior radiologists.
- Using the GPT-4 resulted in much faster performance and greater cost efficiency.
  - Processes reports in **3.5 seconds** compared to humans **25-60+ seconds**.
  - Approximately **$0.03 per report** compared to human labor costs.
  - No fatigue, distraction, or cognitive overload when using GPT-4.

(Radiological Society of North America, 2024)

TIME

COST



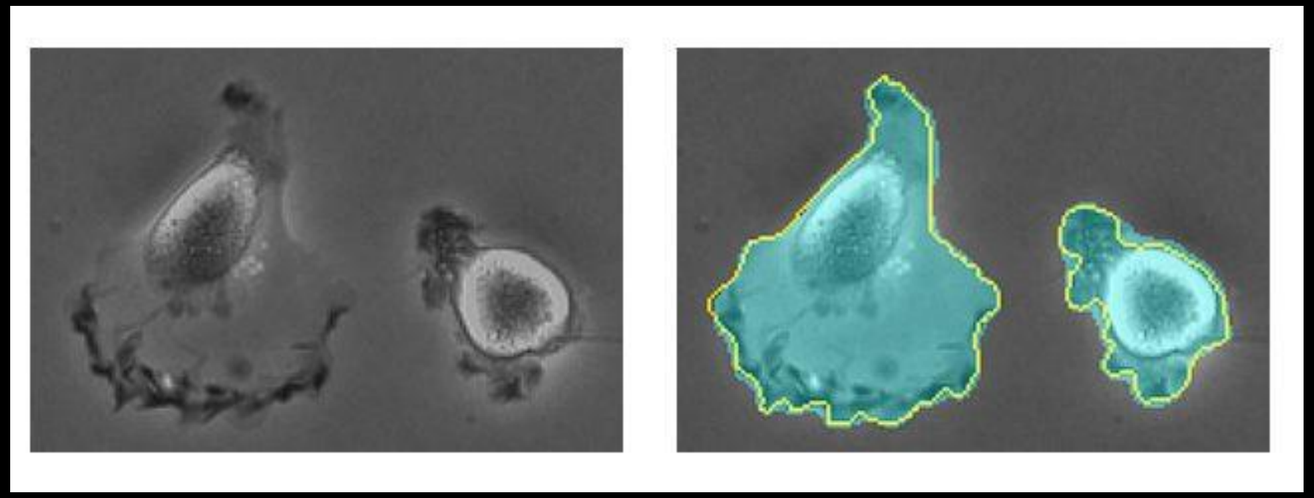
AI vs. Radiologist Rates in Time & Cost

Radiological Society of North America. (2024, April 16). *GPT-4 matches radiologists in detecting errors in radiology reports*. **RSNA.** https://www.rsna.org/media/press/i/2502

How is AI used in Neuroimaging?

- There is a specialized AI model named “U-Net”, which excels at analyzing images and identifying shapes and boundaries.
- AI can reliably identify tumors and measure their size, but it struggled to accurately locate the small, active area of the tumor.

(Innovation District, 2025)



This image shows what the tumor boundaries look like before and after “U-net”.

Klinger. (2024). U-Net: A Comprehensive Guide to Its Architecture and Applications. https://viso.ai/deep-learning/u-net-a-comprehensive-guide-to-its-architecture-and-applications/

AI use in Pediatric Neuroimaging

- Early diagnosis
  - AI automated image analysis can identify small differences within the brain that are associated with neurodevelopmental disorders.
  - This helps with higher survival rates and more effective treatment plans.

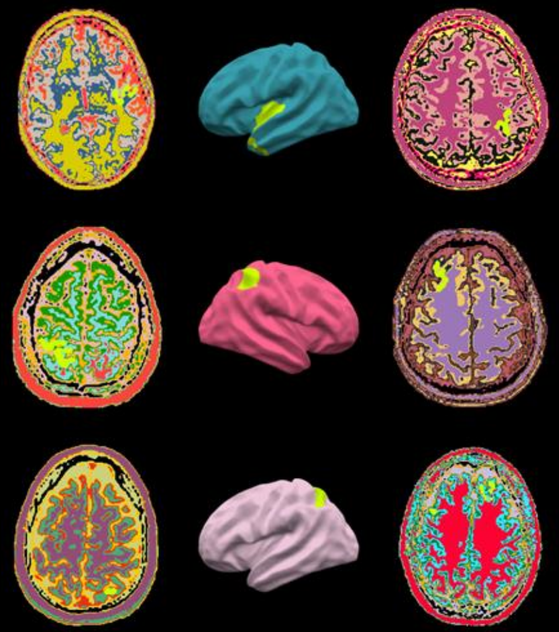
- Tumor segmentation & detection
  - Deep learning neural networks, like CNN (convolutional neural networks) are successful AI tools used for segmenting infant brains and gray-white boundaries.

(Dalbondi da Rocha et al., 2025)

AI use in Pediatric Neuroimaging

- The MELD (Multicenter Epilepsy Lesion Detection) model helps radiologists in identifying focal cortical dysplasias (FCDs), a frequent cause of drug-resistant epilepsy.
  - The MELD examines the patient's MRI by comparing various features like cortical thickness and folding patterns against a large database of scans from healthy and epilepsy individuals.
  - The MELD can spot subtle differences from brain anatomy and show potential lesions that would often go unnoticed by a radiologist. This model is crucial for identifying patients who may benefit from life-changing epilepsy surgery.

(Guarnera et al., 2025)



Adler, S., Wagstyl, K., (2025). MELD Project. https://meldproject.github.io//studies/

Benefits of AI in pediatrics

- Reduced scan time to prevent motion
- Reduced radiation exposure
- Faster results
- Higher accuracy
- Eliminates human error
- More consistency when reading images

(Dalboni da Rocha et al., 2025)

Challenges of AI in pediatrics

- Pediatric brains aren't fully developed
- Few AI models designed for pediatrics
  - AI models designed for adults wouldn't provide accurate results
- Limited data for rare cases & disease detection
- Most PACS systems lack built-in support for AI tools

(Bhatia et al., 2024)

Issues involving pediatric neuroimaging and how AI can solve those challenges.

Table 2. Key issues and respective machine learning solutions in AI-based pediatric neuroimaging for cancer.

Key Issue	Description	Machine Learning Solutions
Limited pediatric data	Scarcity of large, high-quality datasets impedes AI model training.	Transfer learning, federated learning, GANs for data augmentation
Motion artifacts in young patients	Children struggle to stay still during scans, leading to degraded image quality.	AI-based motion correction, CNNs for image denoising
Prolonged scan times	Long MRI scans increase discomfort and require sedation.	Compressed sensing, AI-accelerated MRI reconstruction (e.g., deep CNNs)
Radiation and contrast agent exposure	Pediatric patients are more sensitive to radiation and contrast dyes.	Low-dose imaging with deep learning, contrast-free MRI enhancement with CNNs
Tumor detection and segmentation	Early and precise tumor localization is essential for treatment planning.	CNNs (3D-CNN, ResNet, U-Net, nnU-Net), GANs for data augmentation
Tumor classification and molecular subtyping	Differentiating between tumor types and predicting molecular markers.	Radiomics radiogenomics, CNNs, SVMs, deep learning classifiers
Functional neuroimaging and cognitive deficits	Pediatric brain tumors affect cognitive function, requiring fMRI and other functional imaging.	AI-based functional MRI analysis, machine learning for cognitive pattern recognition (e.g., SVM, CNNs)
Explainability and interpretability of AI	Clinicians need interpretable AI models for trust and adoption.	Explainable AI (XAI), SHAP, LIME, Grad-CAM
Personalized treatment planning	Individualized therapy selection based on imaging and genetic markers.	Multi-modal deep learning (integrating MRI, PET, clinical data)
Predicting treatment outcomes and survival	AI models need to distinguish between real tumor progression and pseudoprogression.	Radiomic feature analysis, deep learning prognostic models, survival prediction frameworks

Dalbondi da Rocha et al., (2025) Table.2 Key issues and respective machine learning solutions in AI-based pediatric neuroimaging for cancer. [Table 2]. Cancers. https://pmc.ncbi.nlm.nih.gov/articles/PMC11852968/

Conclusion

- AI is useful in pediatric neuroimaging, but further research is needed to develop reliable AI tools and data sets to accurately detect neuropathologies in pediatrics.
- Using AI in medical imaging provides faster data collection, reduces costs, and reduces human error.
- AI in pediatric neuroimaging reduces scan time, improves diagnosis, and builds better treatment plans.
- Various AI models enhance radiologists' abilities in diagnosing and guiding patient care.

References

Bhatia, A., Khalvati, F., Ertl-Wagner, B. B., (2024, May 9). Artificial Intelligence in the future landscape of pediatric neuroradiology: Opportunities and challenges. AJNR. American journal of neuroradiology. https://pubmed.ncbi.nlm.nih.gov/38176730/

Childhood Cancer of the Brain and Other Nervous System - Cancer Stat Facts. SEER. seer.cancer.gov/statfacts/html/childbrain.html.

Dalboni da Rocha, J. L., Lai, J., Pandey, P., Myat, P. S. M., Loschinskey, Z., Bag, A. K., & Sitaram, R., (2025, February 12). Artificial Intelligence for neuroimaging in pediatric cancer. Cancers, 17(4),622. https://www.mdpi.com/2072-6694/17/4/622

Gore, J. C., (2020, May). Artificial Intelligence in Medical Imaging. *Magnetic Resonance Imaging,* 68, A1-A4. https://www.sciencedirect.com/science/article/pii/S0730725X19307556?via%3Dihub

References

Guarnera, A., Napolitano, A., Liporace, F., Marconi, F., Rossi-Espagnet, M. C., Gandolfo, C., Romano, A., Bozzao, A., Longo, D., (2025, August 27). *The expanding frontier: The role of Artificial Intelligence in Pediatric Neuroradiology*. Children (Basel, Switzerland). https://pubmed.ncbi.nlm.nih.gov/41006992/

Huang, J., Shlobin, N. A., Lam, S. K., DeCuypere, M., (2022, January). Artificial intelligence applications in Pediatric Brain Tumor Imaging: A systematic review. World neurosurgery. https://pubmed.ncbi.nlm.nih.gov/34648981/

Innovation District. (2025, July 14). *New advances in AI help doctors understand pediatric brain tumors*. https://innovationdistrict.childrensnational.org/new-advances-in-ai-help-doctors-understand-pediatric-brain-tumors/

National Cancer Institute. (2025, April 24). *Childhood cancers*. U.S. Department of Health and Human Services. https://www.cancer.gov/types/childhood-cancers cancer.gov

Radiological Society of North America. (2024, April 16). *GPT-4 matches radiologists in detecting errors in radiology reports*. RSNA. https://www.rsna.org/media/press/i/2502

Image References

Adler, S., Wagstyl, K., (2025). MELD Project. https://meldproject.github.io//studies/

“Childhood Cancer of the Brain and Other Nervous System - Cancer Stat Facts.” SEER, seer.cancer.gov/statfacts/html/childbrain.html.

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Klinger. (2024). U-Net: A Comprehensive Guide to Its Architecture and Applications. https://viso.ai/deep-learning/u-net-a-comprehensive-guide-to-its-architecture-and-applications/

Radiological Society of North America. (2024, April 16). GPT-4 matches radiologists in detecting errors in radiology reports. RSNA. https://www.rsna.org/media/press/i/2502