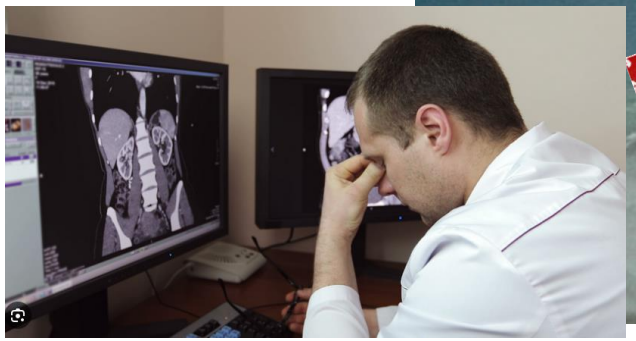
SESSION VII: CLINICAL ADOPTION OF NEW IMAGING TECHNOLOGIES

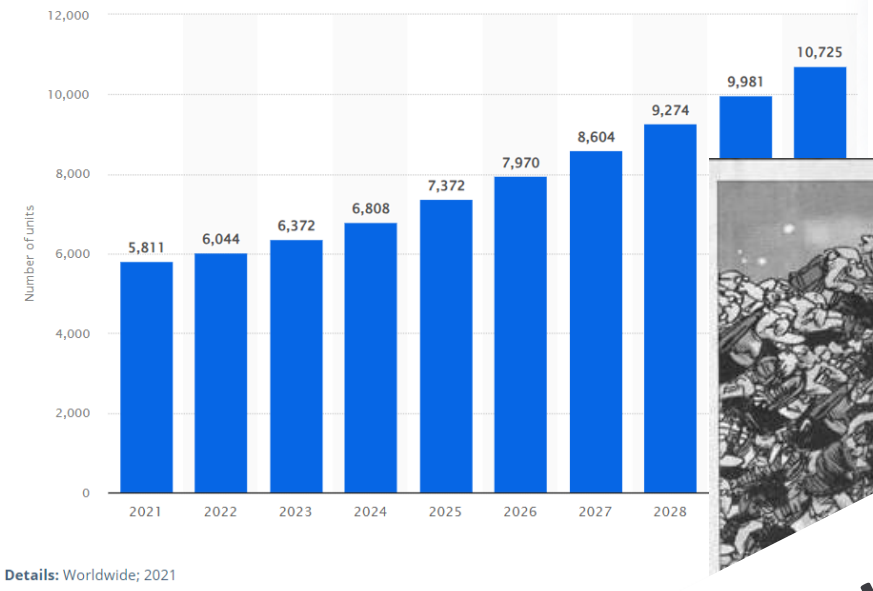
Where do we go from here in MRI? - Academic Perspective

Konstantin Nikolaou, Dpt. of Radiology, University Hospital Tuebingen

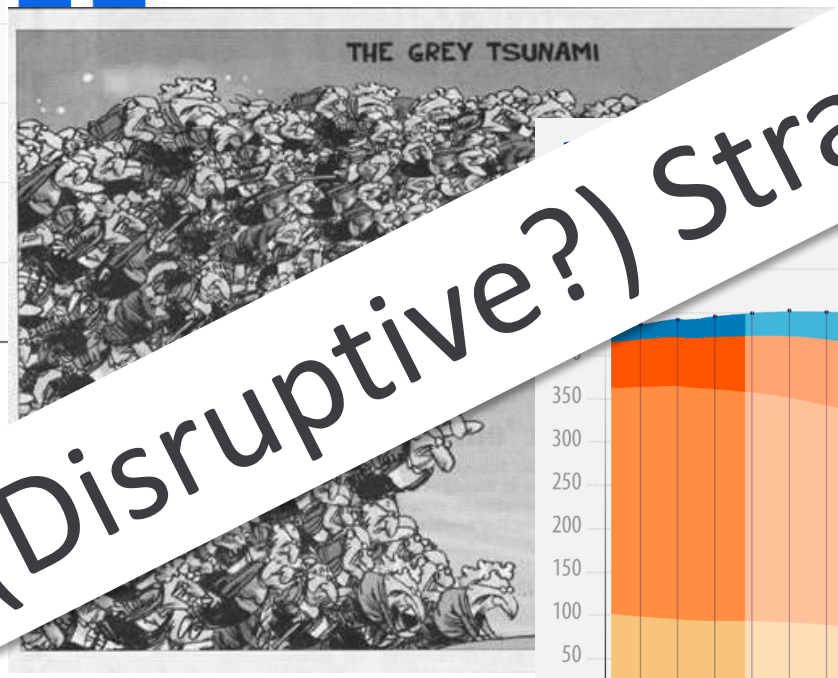
Advancing MRI – how do we respond to today´s challenges?



Challenge 1: Workload & Staff Shortage

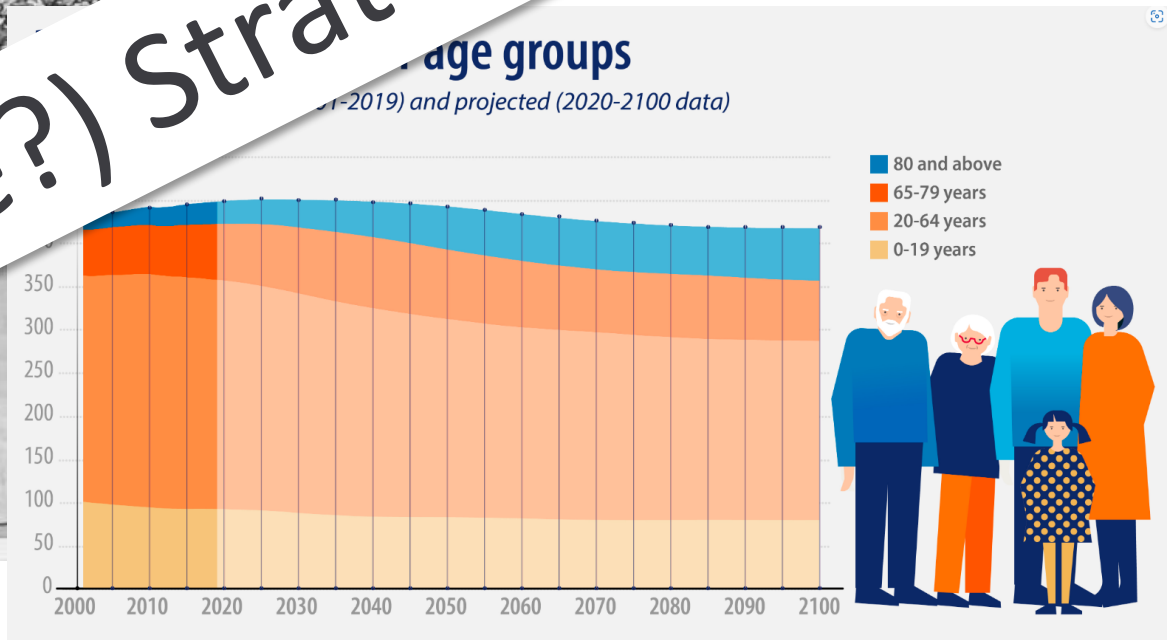


Details: Worldwide; 2021



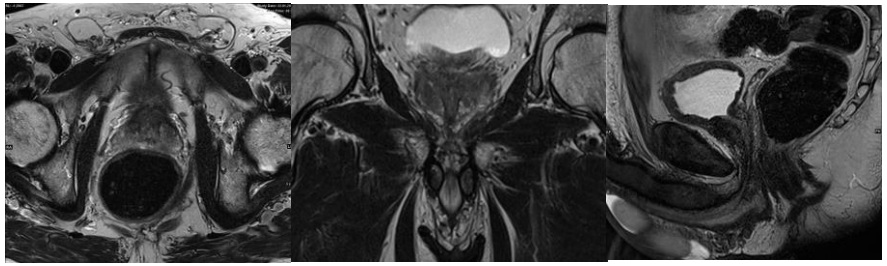
New (Disruptive?) Strategies!

- Increasing need f
- More & olde
- Lack of staff



State-of-the-art: Optimizing Workflows…

Manual Planning
02:00 min



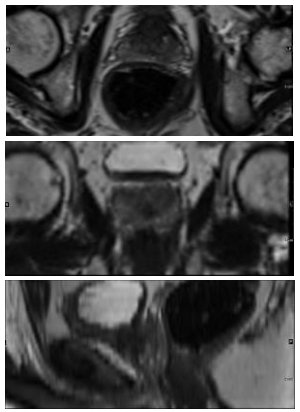
T2w in 3 planes 10:21 min

on (B 2000)
min

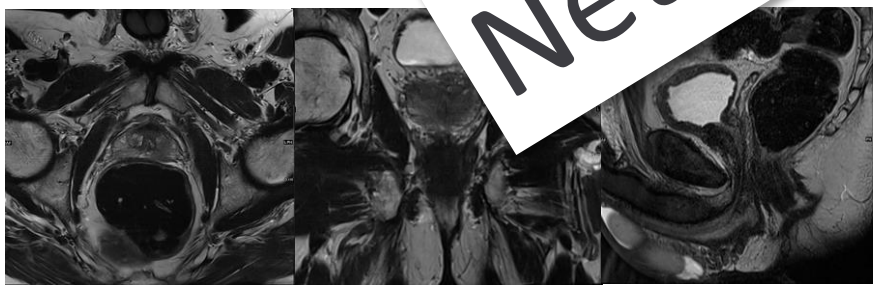
ADC Maps

Standard reporting

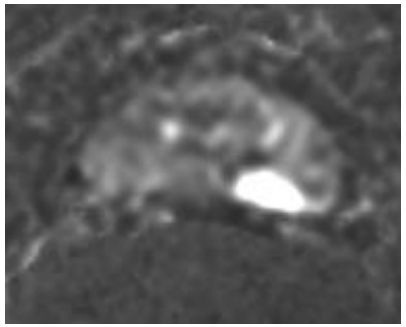
Net time -50%



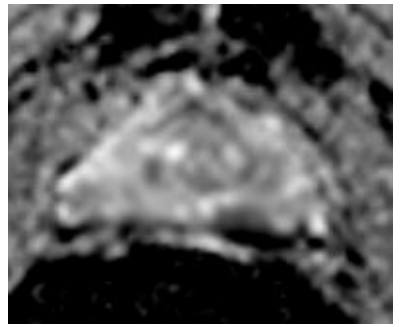
Automated Planning
01:00 min



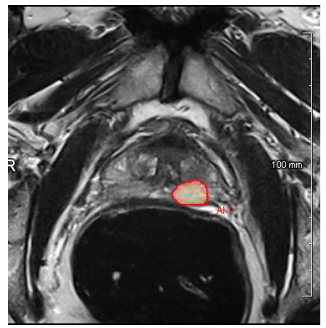
T2w DL in 3 planes 03:50 min



DL Epi Diffusion (B 2000)
03:10 min



ADC Maps



Automated detection
and classification

Gassenmaier, Afat, et al., Invest Radiol 2021

Rethink our protocols → What is REALLY needed?

Focused Abbreviated Survey MRI Protocols for Brain and Spine Imaging

RadioGraphics 2023; 43(6)

Laura B. Eisenmenger, MD • Anthony Peret, MD* • Grant S. Roberts, PhD • Alma Spahic, MSc • Chenwei Tang, BSc • Anthony D. Kuner, MD*
Allison M. Grayev, MD • Aaron S. Field, MD • Howard A. Rowley, MD • Tabassum A. Kennedy, MD

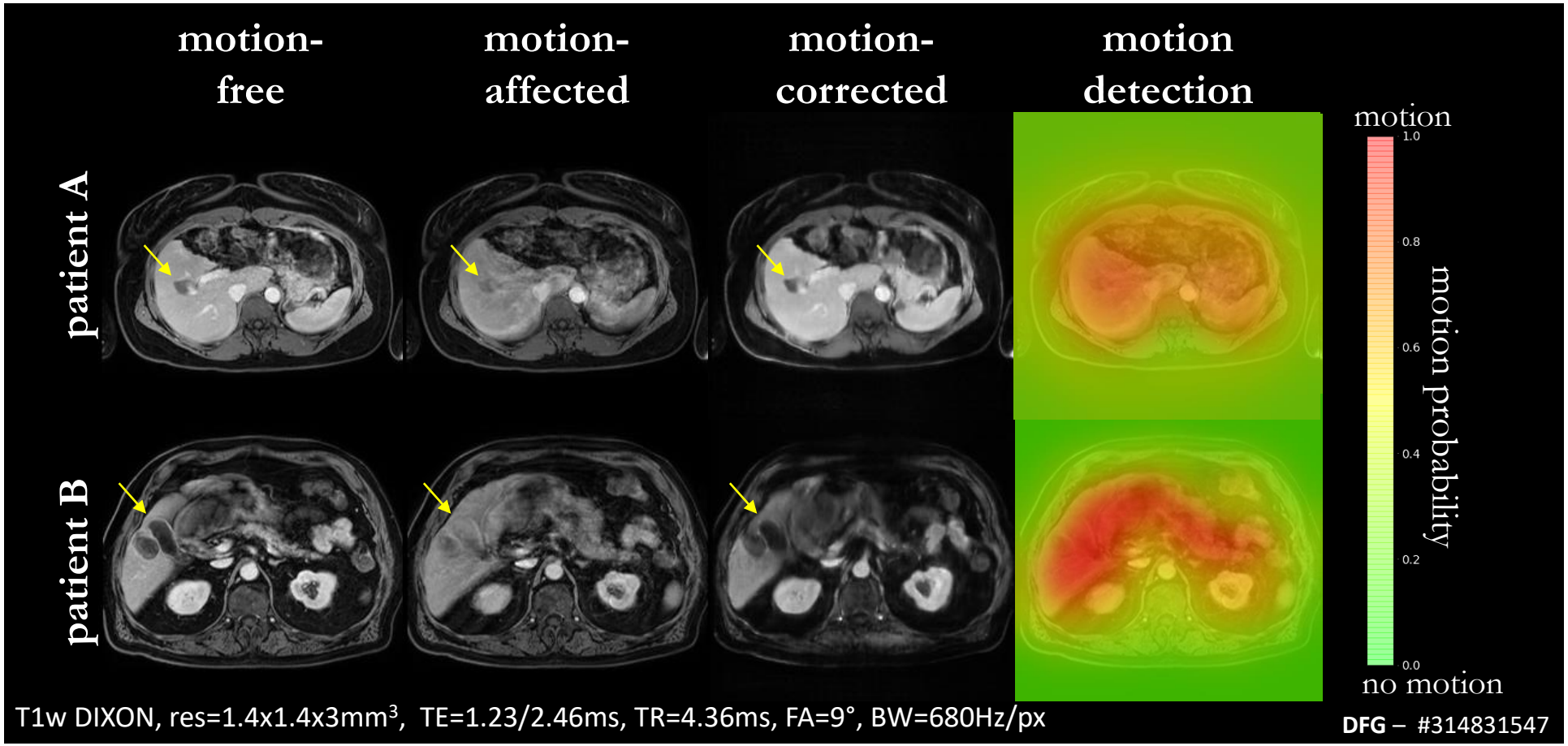
FAST stroke without contrast MRI (<6min)

(80-year old man with aphasia for approximately 4 hours)

Table 2: FAST MRI Protocols

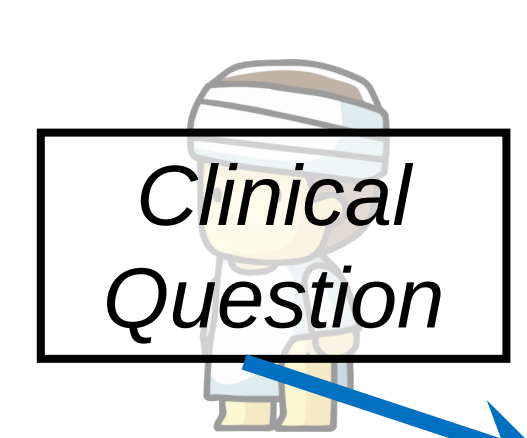
MRI Protocol*	Sequences	Imaging Planes
FAST stroke with contrast (7 min, 5 sec)	Pre-Gd:	
	DW1, TOF FSPGR circle of Willis (optional)	Axial
	T1W FSE	Sagittal
	Post-Gd:	
	DSC PWI, T2W SSFSE, T2*W GRE EPI, T2W FLAIR, T1W FSPGR (optional)	Axial
	3D PCA	Sagittal
	T1W FSE (optional)	Coronal
FAST stroke without contrast (5 min, 53 sec)	DWI, TOF FSPGR circle of Willis (optional), T2W SSFSE, T2*W GRE EPI, T2W FLAIR	Axial
	T1W FSE, 3D PCA	Sagittal
FAST brain with contrast (12 min, 37 sec)	Pre-Gd:	
	DWI, T2*W GRE EPI	Axial
	T1W FSE	Sagittal
	T2W SSFSE	Axial + coronal + sagittal
	Post-Gd:	
	DSC PWI, T1W FSPGR	Axial
	T2W FLAIR	Sagittal
	T1W FSE	Coronal
FAST brain without contrast (3 min, 49 sec)	DWI, T2*W GRE EPI, T2W SSFSE, T2W FLAIR	Axial
	T1W FSE	Sagittal
FAST spine (17 min, 2 sec)	Cervical, thoracic, and lumbar T2W STIR FSE	Sagittal
	Cervical, thoracic, and lumbar T1W FSE	Sagittal + axial
Pediatric quick brain (1 min)	T2W SSFSE	Axial + coronal + sagittal
	EPIMix (optional)	Axial
Pediatric quick spine (4 min, 25 sec)	T2W SSFSE (all levels)	Axial
	T2W SSFSE (cervicothoracic and thoracolumbar)	Sagittal + coronal
	T1W FSE (T11 to coccyx) (optional)	Axial + sagittal

Real-time AI-based image quality control



Küstner et al. *MRM* 2020

Adaptive Protocoling



Clinical Question

Electronic Medical Record

Deep Learning Algorithm (MRI)

Highest Probability Sequence(s)

Question Answered? (>95%)

No

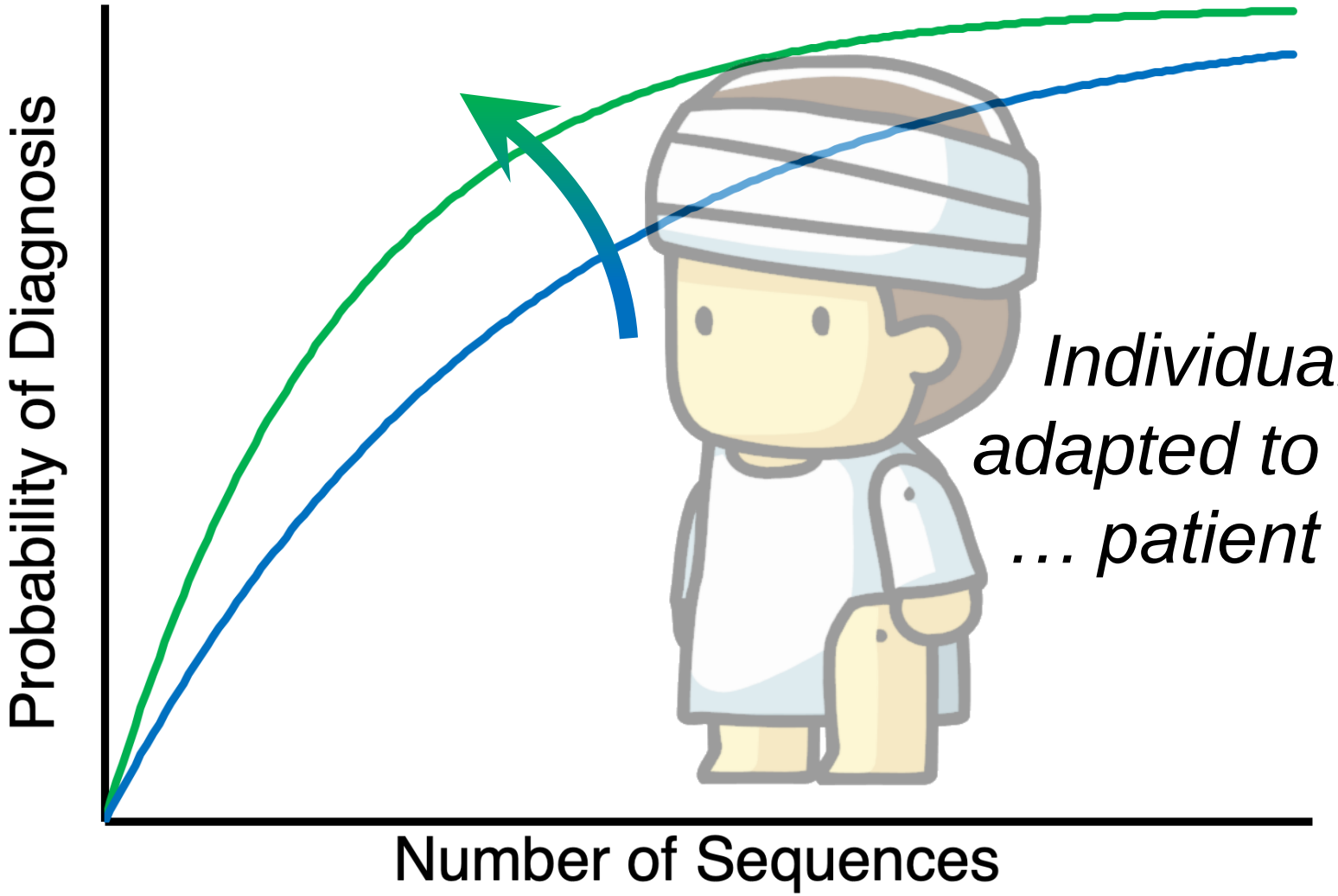
Feed images back into DL algorithm

Yes

STOP

Scott Reeder, MD, PhD and Diego Hernando, PhD recently received an R01 grant from the Department of Health and Human Services (DHHS) in the National Institutes of Health (NIH) for their project, "Fully Automated High-Throughput Quantitative MRI of the Liver." The team was granted nearly $1.5 million in direct costs and a total award of $2.1 million to be used between 04/08/2022 – 12/31/2025.

Real Time Protocol Adjustment

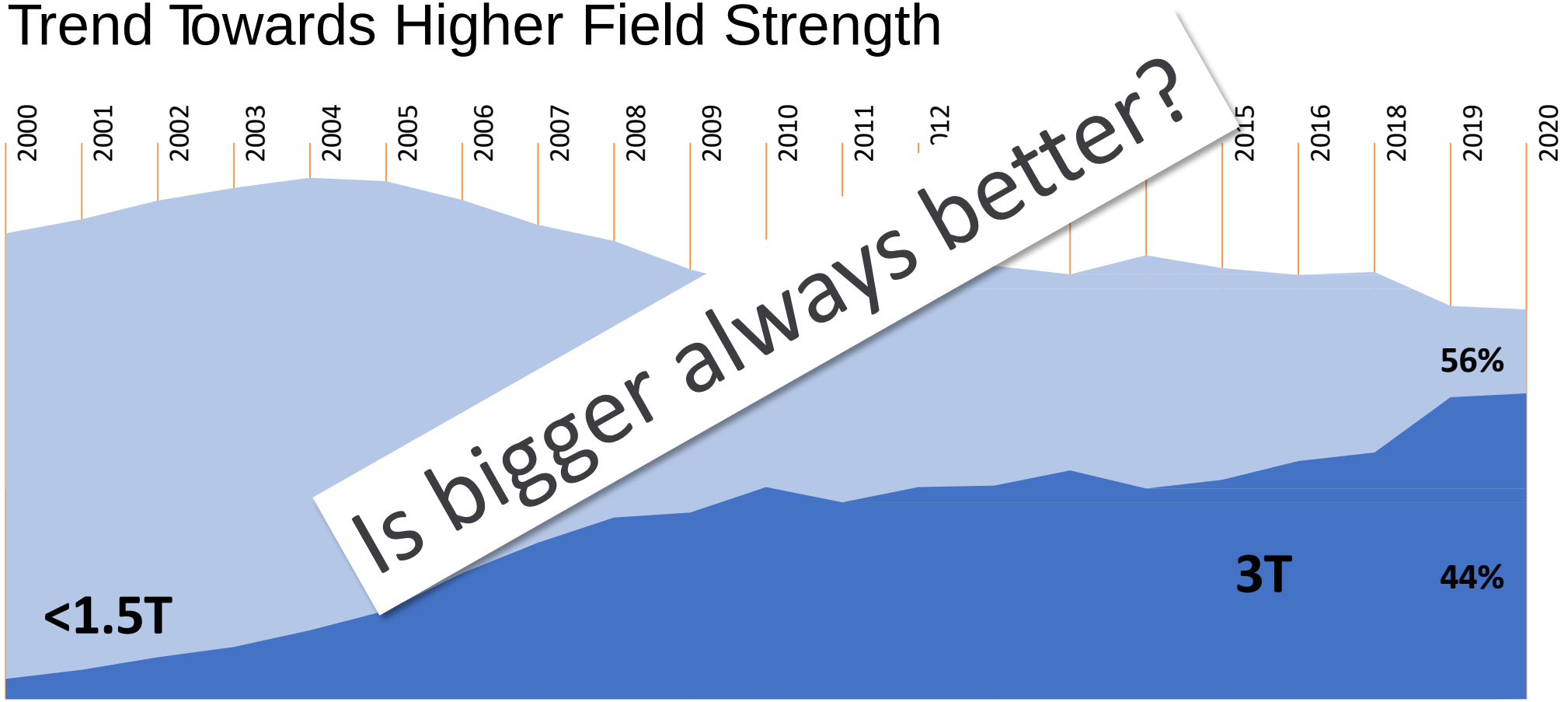


Individual protocols adapted to each patient … patient centric MRI

Courtesy of Scott Reeder

Challenge 2: Sustainability

Trend Towards Higher Field Strength



Siemens Healthineers installed base as of 2021

Energy Consumption of MRI

Radiology

ORIGINAL RESEARCH · HEALTH POLICY AND PRACTICE

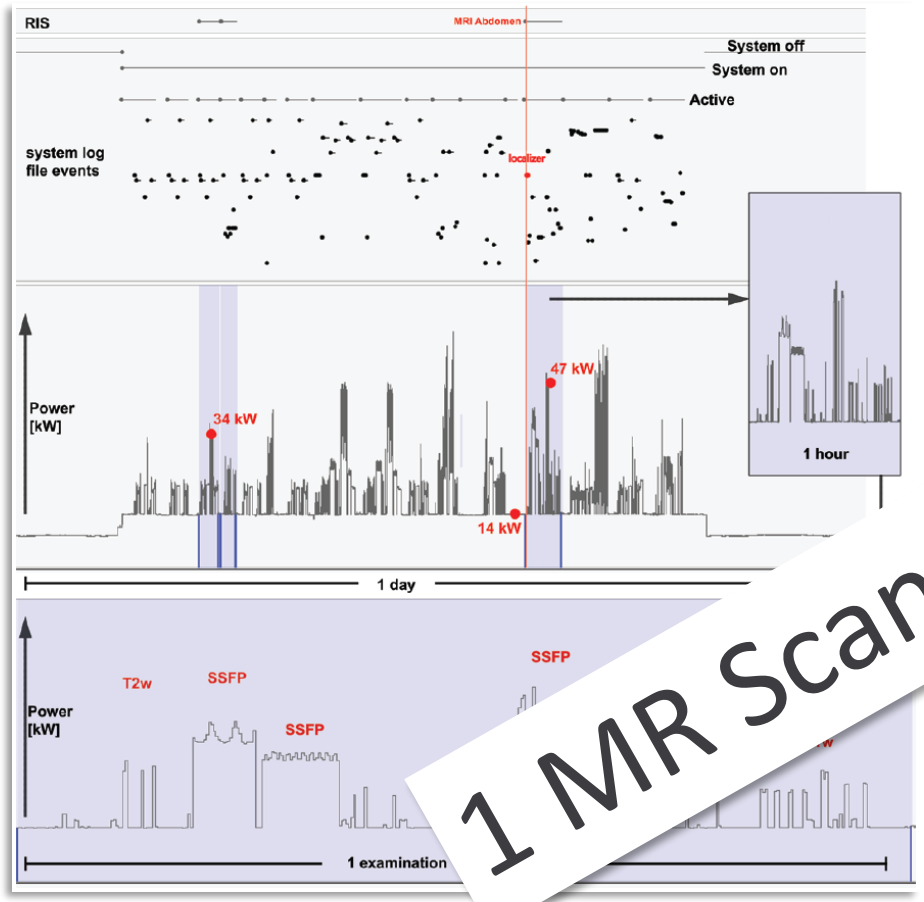
The Energy Consumption of Radiology: Energy- and Cost-saving Opportunities for CT and MRI Operation

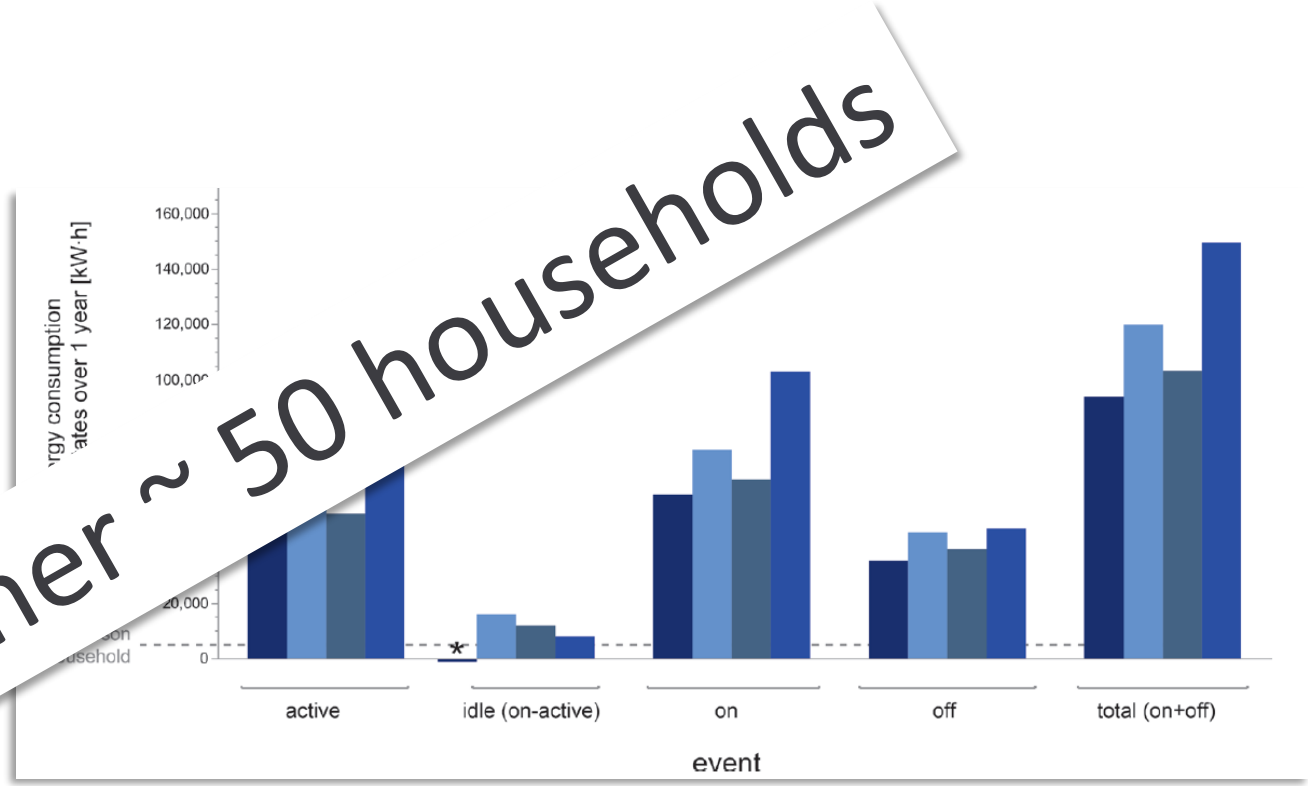
Tobias Heye, MD • Roland Knoerl, MBA, B Eng • Thomas Wehrle, Dipl-Ing • Daniel Mangold • Alessandro Cerminara • Michael Loser, PhD • Martin Plumeyer, Dipl-Ing • Markus Degen, PhD • Rahel Lüthy, MSc • Dominique Brodbeck, PhD • Elmar Merkle, MD

Radiology 2020; 295:593–605

- ~135.000 kWh/MR scanner/year (~25.000 Euro energy costs per year, ~20 kWh per exam)
- For MRI, **one-third of energy consumption was attributed to the system-off state** owing to the need for constant helium cooling and cooling head operation.
- In this university institution, CT and MRI installation contributed to **4% of our total yearly hospital energy consumption.**
- 3T units consume about **50% more energy** than 1.5T

Energy Consumption of MRI

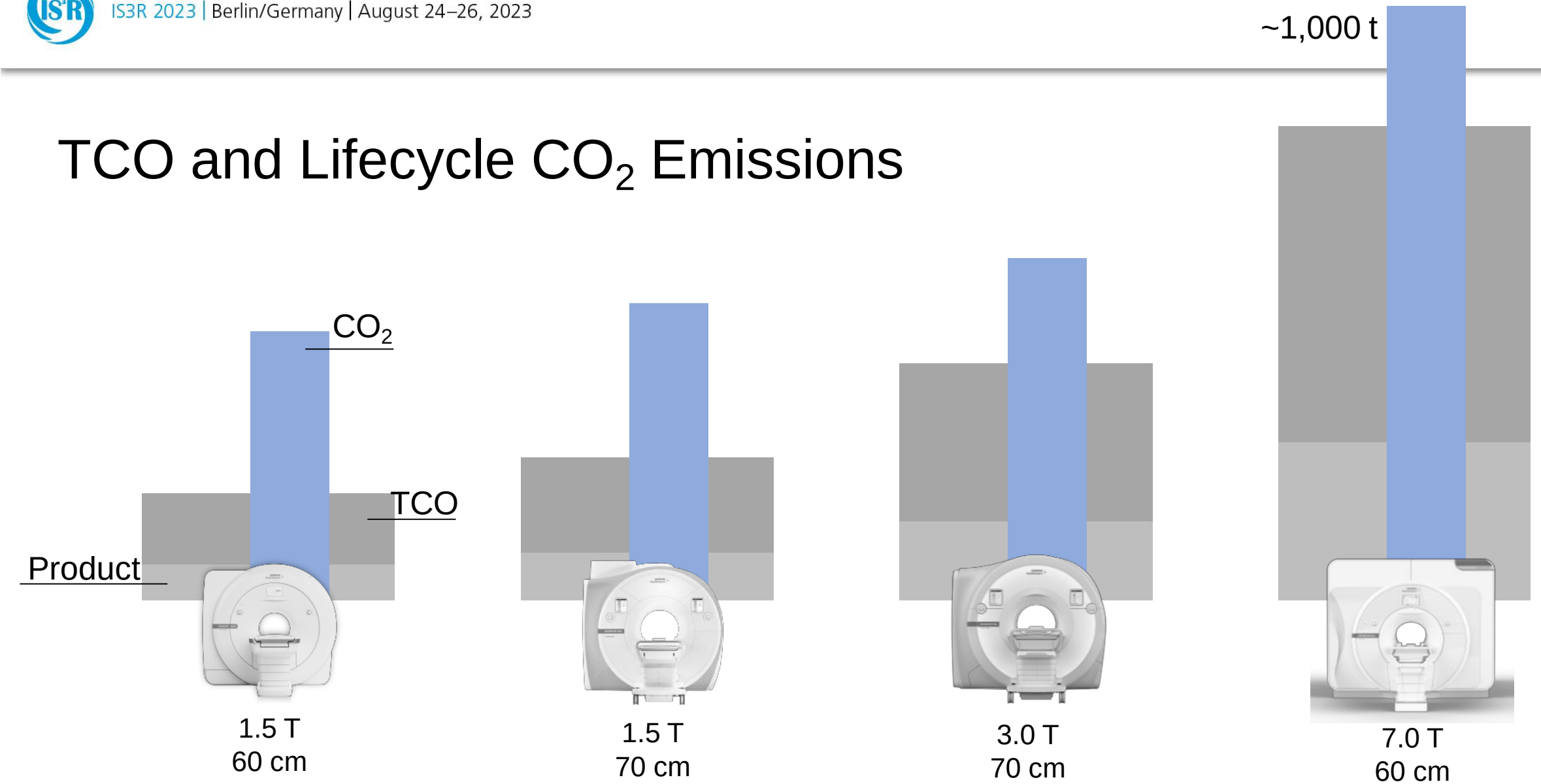




1 MR Scanner ~ 50 households

Heye et al. Radiology 2020

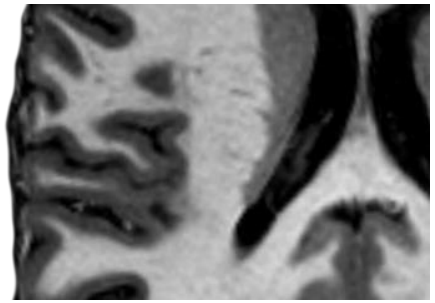
TCO and Lifecycle CO_2 Emissions



Courtesy of E. Merkle, Basel

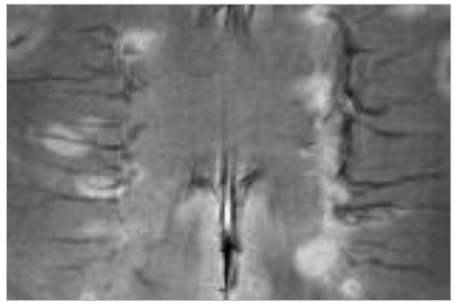
Why you may still need a 7T MR system

- Research – gaining new knowledge
- Better understanding of physiology/pathophysiology
- Clinical indications with some value



unmasking subtle malformations

Epilepsy

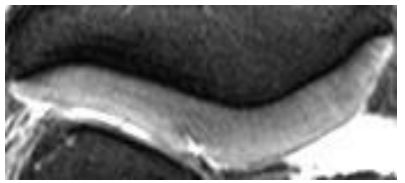


markers of progression & precise differential diagnosis

Multiple Sclerosis

precise characterization of aneurysms, vasculitis, small vessel diseases

Cerebrovascular Diseases



Assessment of cartilage damage for restauration procedures

Arthritis & Cartilage degeneration

Detailed depiction of subtle tears

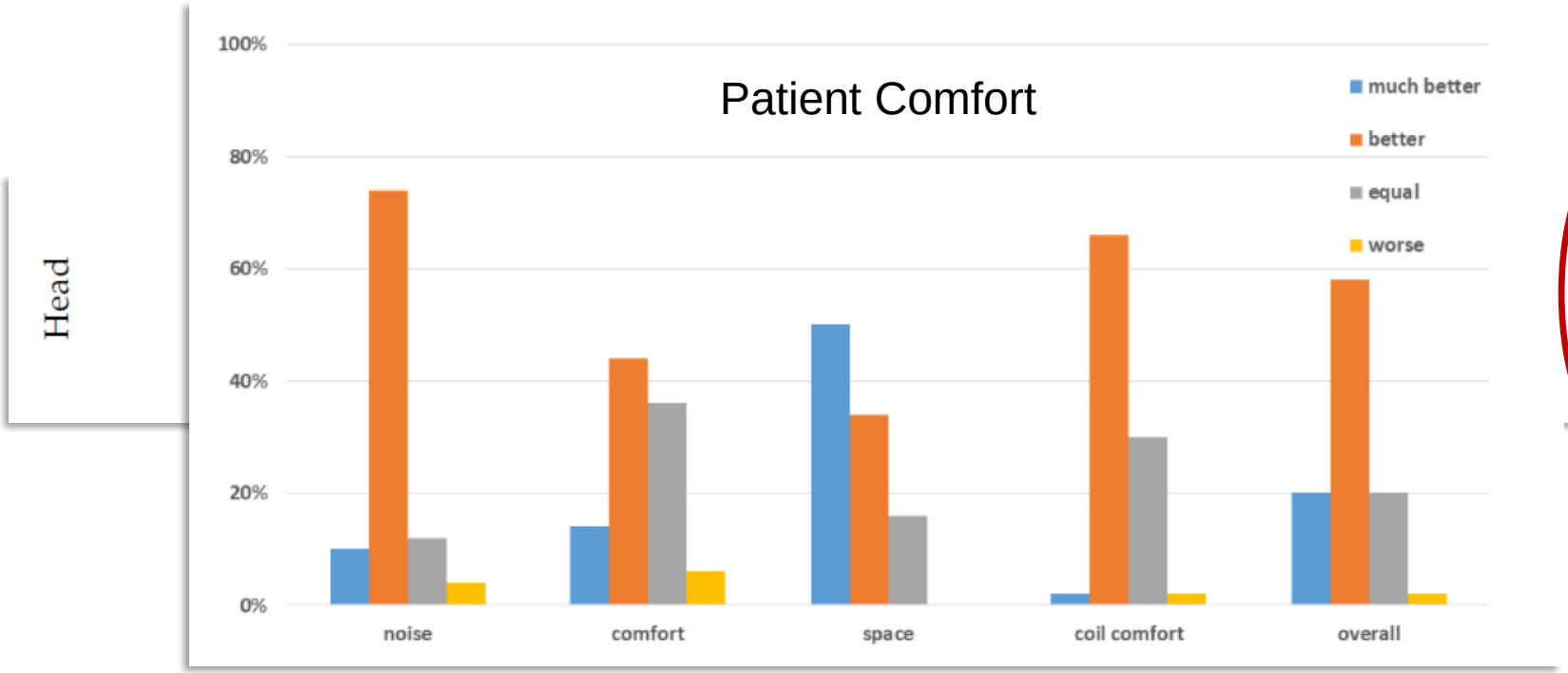
Meniscal & Ligament tears

New technologies → lower field strenghts?

0.55 Tesla MRI

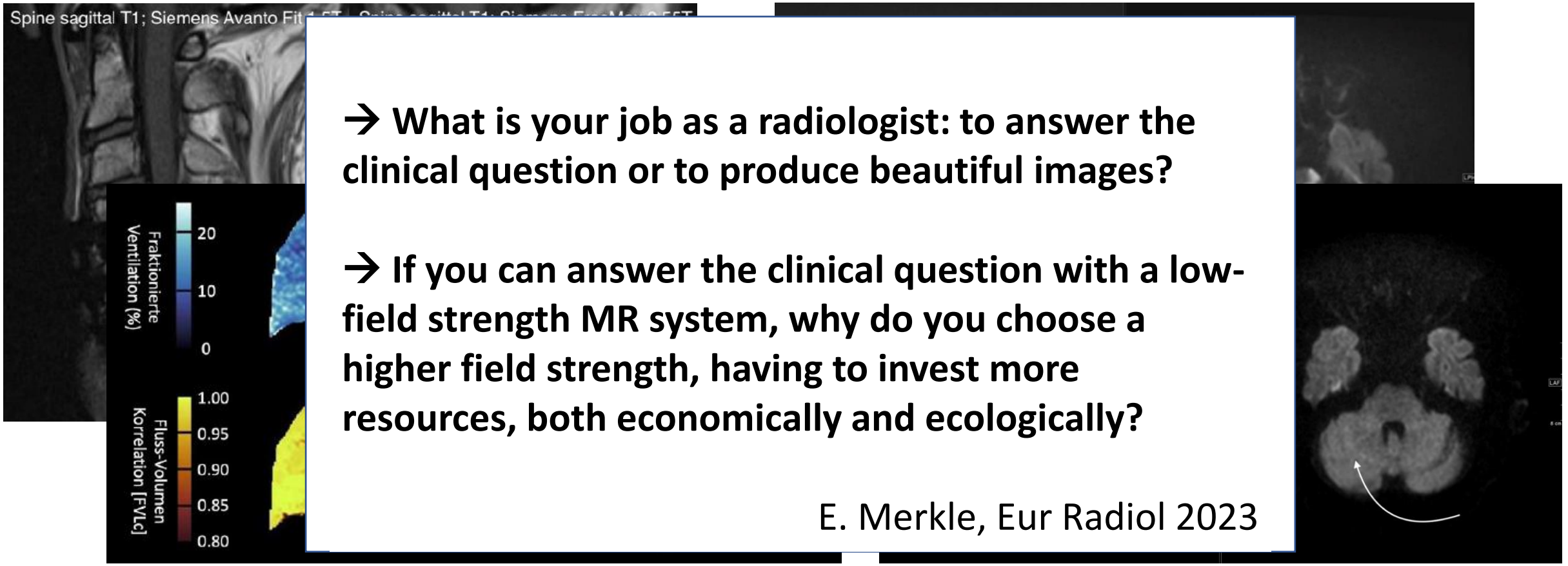
Pro:
Running Costs
Installation Costs
Patient Comfort

Con:
Scan Duration
Overall Image Quality



Merke E., Eur Radiol 2023
Rusche T, et al., J Clin Med 2022

New technologies → lower field strenghts?



→ What is your job as a radiologist: to answer the clinical question or to produce beautiful images?

→ If you can answer the clinical question with a low-field strength MR system, why do you choose a higher field strength, having to invest more resources, both economically and ecologically?

E. Merkle, Eur Radiol 2023

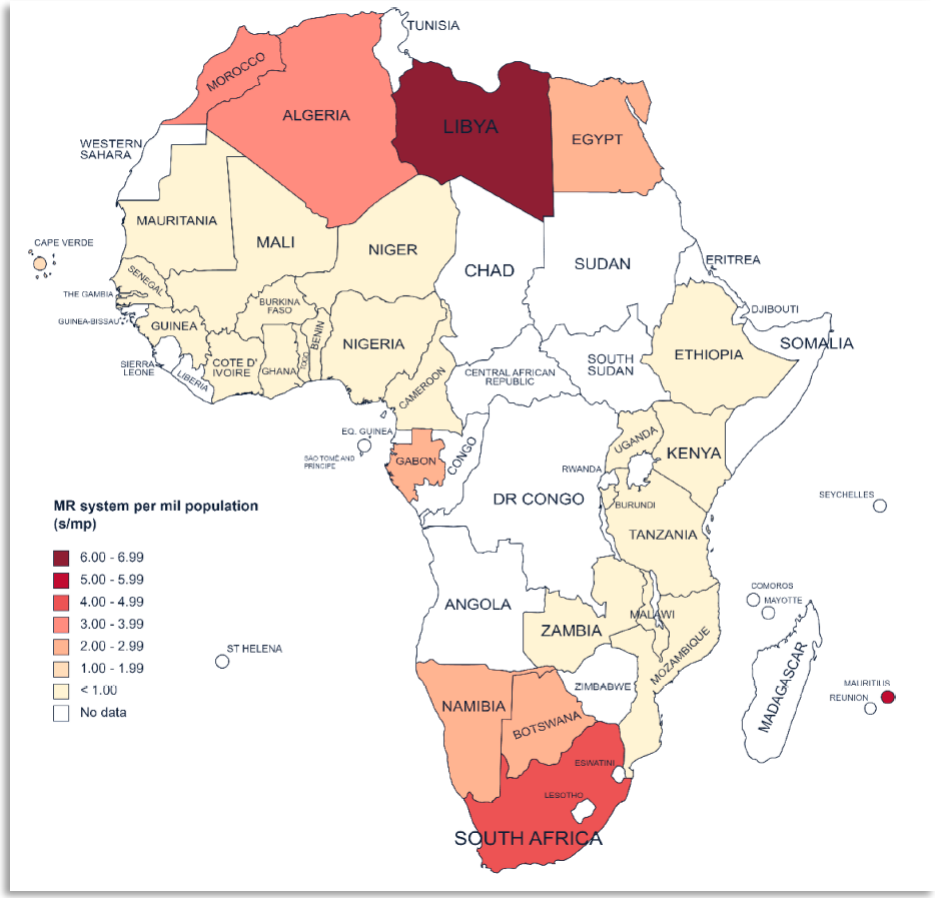
May M, et al., Radiologe 2022
Rusche T, et al., J Clin Med 2022

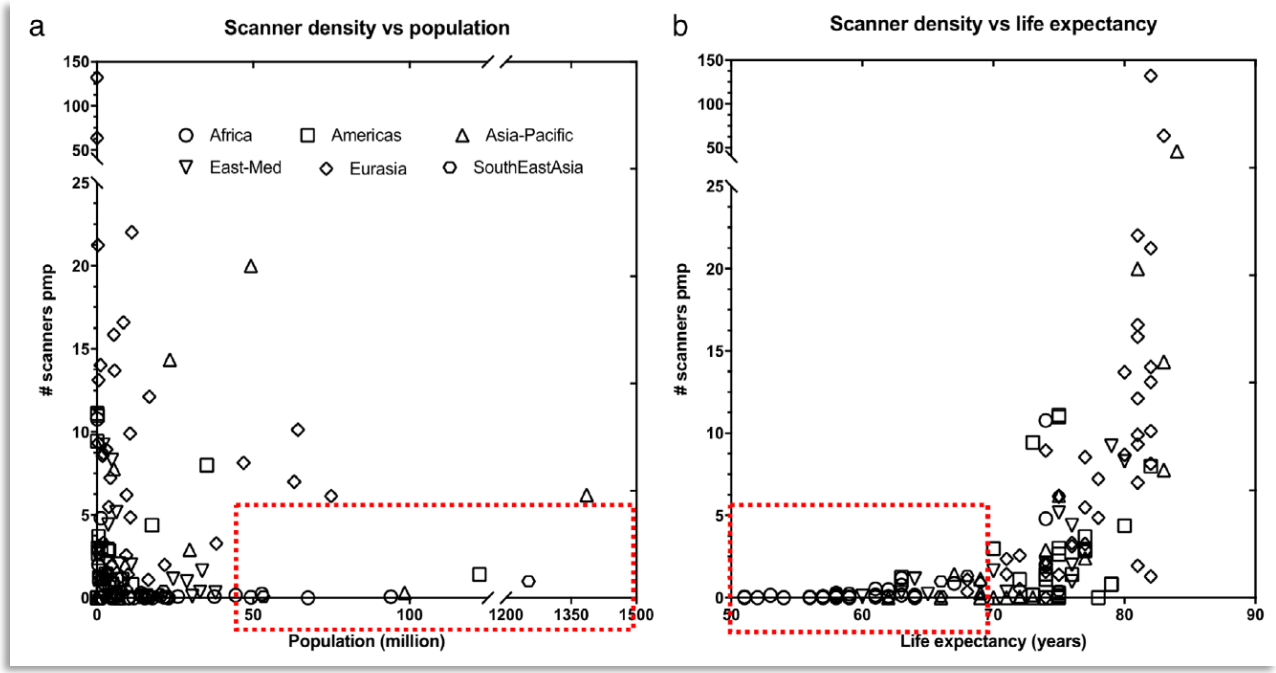
Challenge 3: Accessability

Lambaréné is a town and the capital of Moyen-Ogooué in Gabon. It has a population of 38,775 and is located 75 kilometres south of the equator.

The Wall Street Journal, August 2023

Access to high-quality care





Geethanath S, et al., J. MAGN. RESON. IMAGING (2019) 49
Hasford F., et al., PHYSICA MEDICA (2022) 46

Bring MRI to the patients → Ultra Low Field Mobile MR Scanners

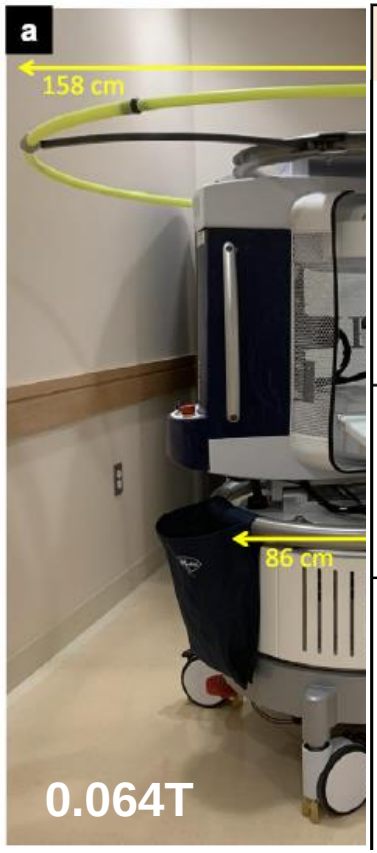
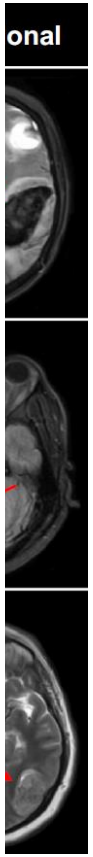


Table 2 Portable MRI examination time compared to conventional MRI.

Portable MRI[a]		Conventional MRI[b]	
Scan preparation	**Time (min:s)**	**Scan preparation**	**Time (min:s)**
Prepare ICU room for pMRI scanne	01:28 ± 0:02	Prepare patient for transport	05:56 ± 0:11
Move scanner from hall to head of	00:49 ± 0:01	Transport from ICU to holding room of radiology suite	08:33 ± 0:12
Position patient in pMRI scanner an acquisition	06:07 ± 0:09	Prepare patient for entry into high field environment in holding room	15:16 ± 0:43
		Transport from holding room, position in MRI gantry, and initialize scan acquisition	05:05 ± 0:04
Sequence acquisition	**Time (min:s)**	**Sequence acquisition**	**Time (min:s)**
Pre-scan calibration	01:03	Pre-scan calibration	00:21 ± 0:01
Localizer	00:18	Localizer	00:19 ± 0:01
T2W (axial)	07:01	T2W (axial)	01:55 ± 0:01
FLAIR (axial)	09:29	FLAIR (axial)	02:47 ± 0:02
Scan termination	**Time (min:s)**	**Scan termination**	**Time (min:s)**
Remove patient from pMRI scanne	00:44 ± 0:01	Remove patient from MRI gantry and transport to radiology holding room	03:03 ± 0:03
Remove scanner from ICU room	00:34 ± 0:01	Prepare patient for transport from radiology holding room to ICU	13:14 ± 0:11
Reset patient ICU room	03:08 ± 0:02	Transport patient from radiology suite holding room to ICU	07:11 ± 0:04
		Reset patient ICU room	04:21 ± 0:18
Total Time:	30:21	Total time:	67:36



Sheth KN et al: JAMA Neurol, 2020
Mazurek MH et al: Nat Commun, 2021

Ultra Low Field Mobile MR Scanne

B Bedside point-of-care magnetic resonance imaging

0.064 -

- Dr pe
- 0 kg
- power supply
- cooling needs
- No room shielding No table needed
- No safety requirements
- No extra monitoring
- Excellent patient access
- Limited scan range
- Image quality ±

Outlook:
AI-based Optimization of Acqusition & Image Quality

Sheth KN et al: JAMA Neurol, 2020
Mazurek MH et al: Nat Commun, 2021

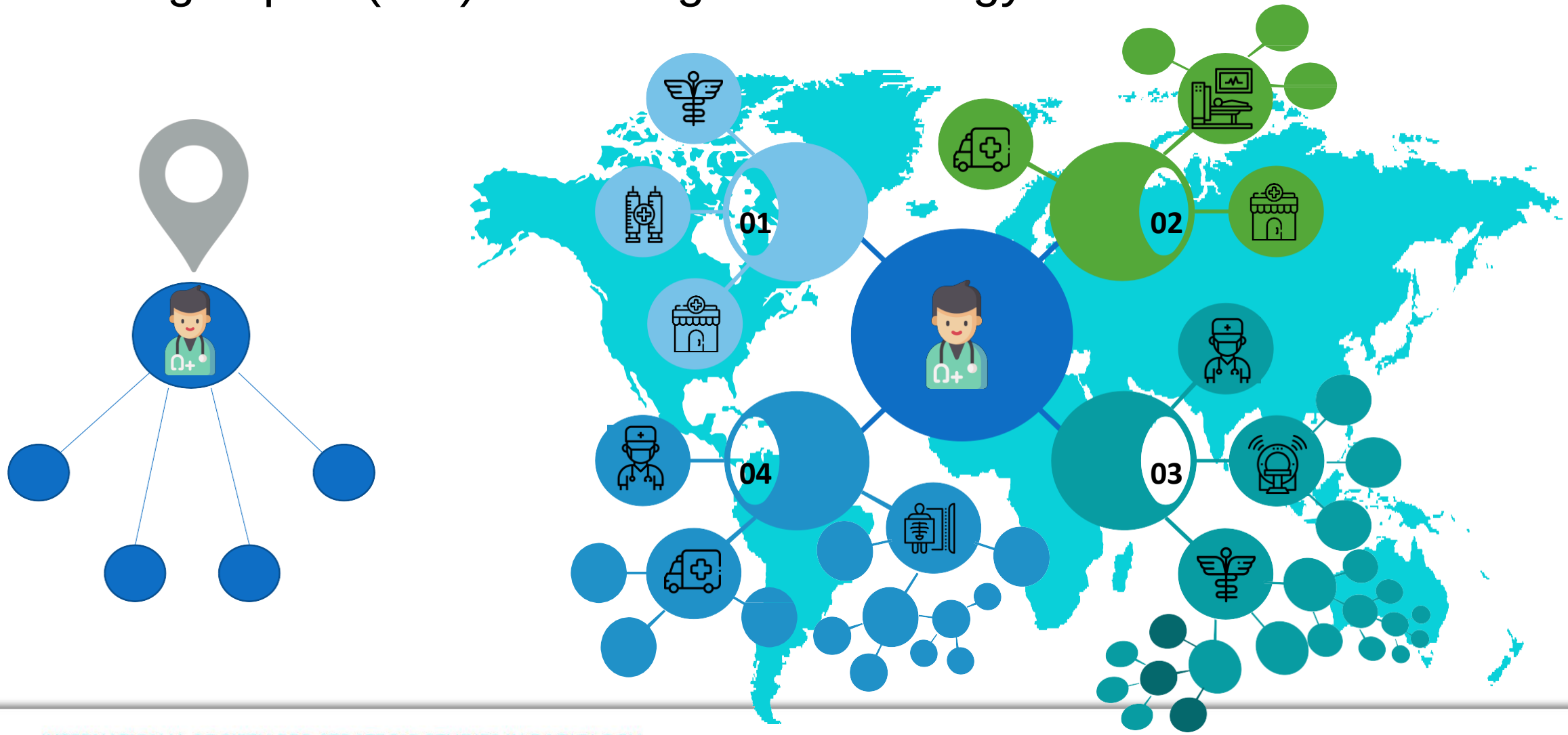
Take Home Point – is bigger always better?

With an ever growing MR market, there is substantial room on both sides of the field strength spectrum

- research opportunities
- business opportunities
- patient care

Challenge 3: Accessability

Providing expert (MR) knowledge in Radiology – The Vision

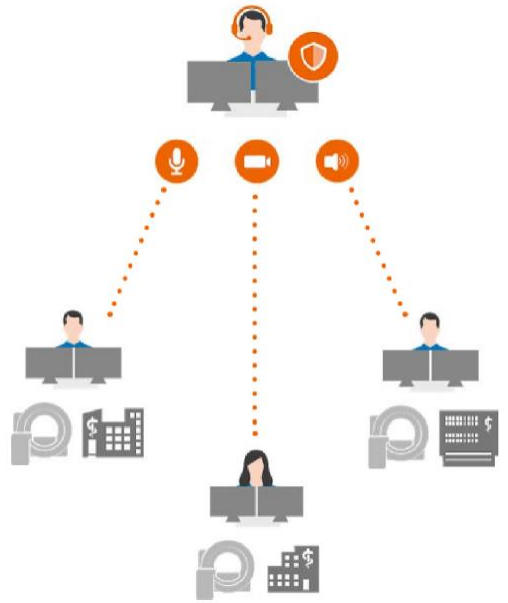


Courtesy of J. Yamamura

Adopting remote scanning: Key considerations

Introducing remote scanning technology has the potential…

- To **bring quality care to patients** to more consistently, sooner, closer to home
- to **support training** and share skills of experienced radiographers across multiple locations, even countries.
- to enable **expert supervision**
- to introduce a **wider utilization of the modality** and workforce.



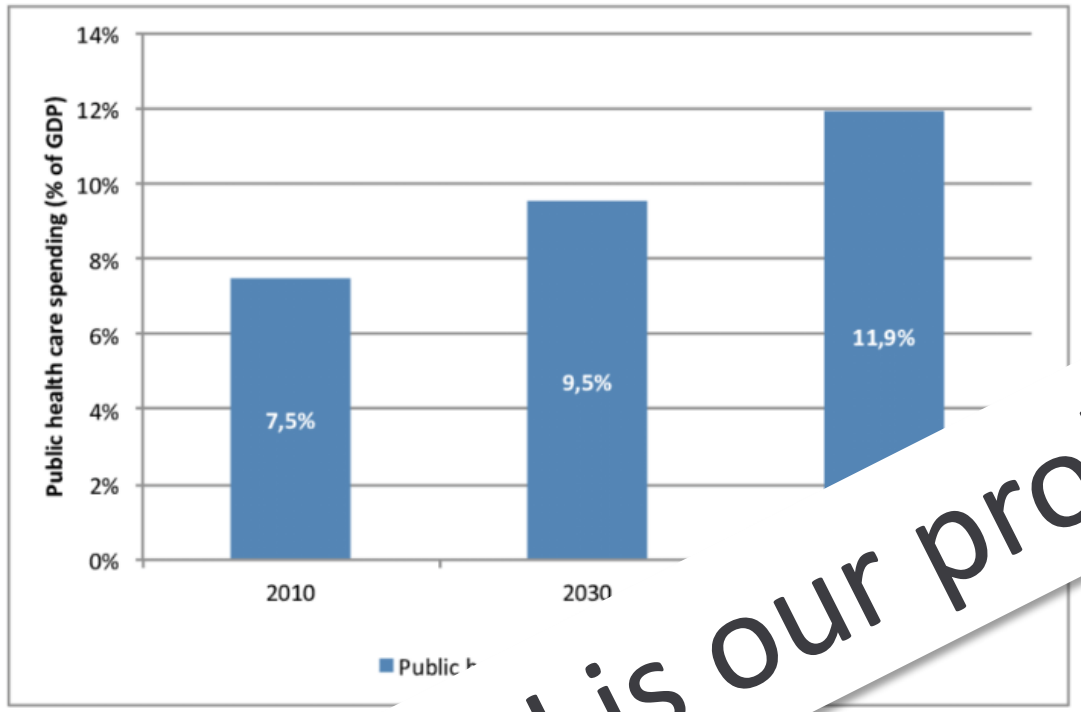
Radiography28 (2022) 739e745

Adopting remote scanning: Open questions

- "**Who's in the room** with the patient and positioning them?"
- "Does this jeopardize **accreditation**?"
- "How much does this **cost**?"
- "What **software/infrastructure** is necessary on our MRI units to utilize remote scanning capabilities?"
- "What's the **return on investment**?"
- "Will this affect the **quality of care** the patient receives?"
- "What happens in the event of an **emergency**?"

Acceptance by our technicians!

Challenge 4: Creating Value



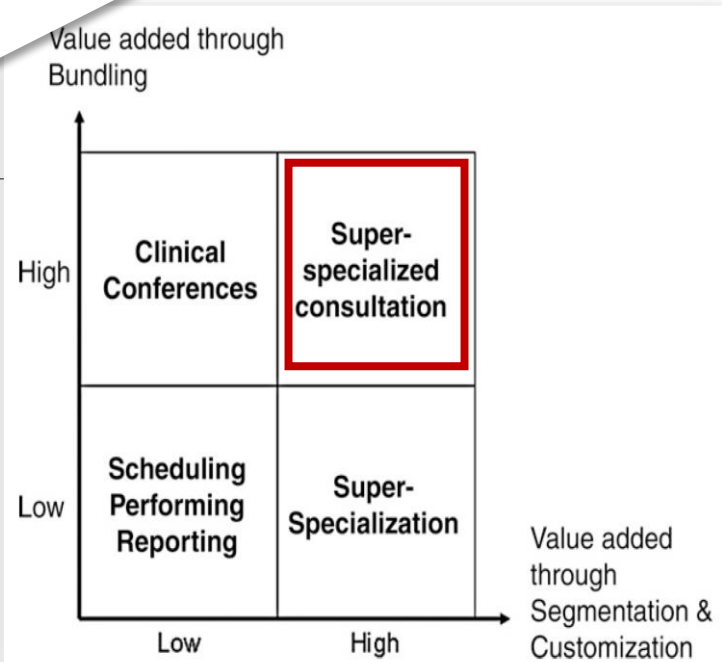
IMF Projections of public health c… …ne Scenario)

PERSPECTIVES

…, MD, PhD

…diology: Volume 256: Number 2

…n Radiology:
…pportunity?[1]



Radiology

MRI is our problem-solving tool!

Creating Value: Establishing robust MRI imaging Biomarker

European Radiology (2022) 32:8617–8628
https://doi.org/10.1007/s00330-022-08880-7

MAGNETIC RESONANCE

Quantification and reduction of cross-vendor variation in multicenter DWI MR imaging: results of the Cancer Core Europe imaging task force

Oliver Lukas Sedlaczek[1,2,3] · Jens Kleesiek[1] · Ferdia A. Gallagher[4] · Jacob Murray[1] · Sebastian Prinz[1] · Raquel Perez-Lopez[5] · Evia Sala[6] · Caroline Caramella[7] · Sebastian Diffetock[7] · Nathalie Lassau[7] · Andrew N. Priest[4,8] · Chikako Suzuki[9] · Roberto Vargas[10] · Tommaso Giandini[11] · Marta Vaiani[12] · Antonella Messina[12] · Lennart K. Blomqvist[9] · Regina G. H. Beets-Tan[13] · Petra Oberrauch[2] · Heinz-Peter Schlemmer[1,2] · Michael Bach[1] · for the CCE – Imaging Task Force

- Robust (companion) imaging biomarkers
- Prediction and prognosis
- New solutions: MR-guided interventions

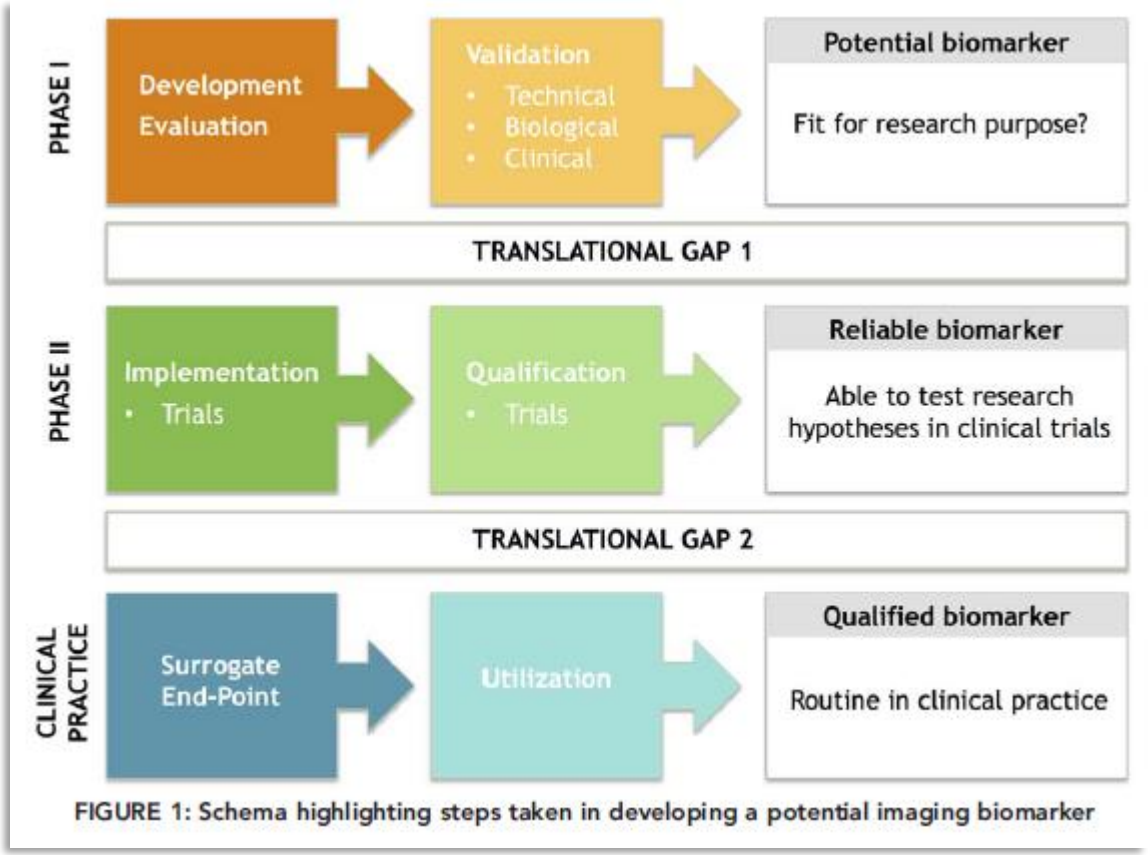


FIGURE 1: Schema highlighting steps taken in developing a potential imaging biomarker

Goh V. et al. JMRI 2019
Sedlaczek O. et al., Eur Radiol 2022

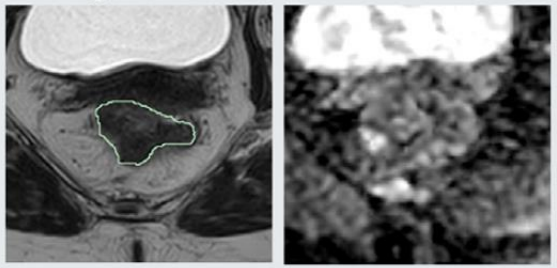
Creating Value: MR-guided Radiotherapy

Pretreatment

Patient selection and treatment decisions

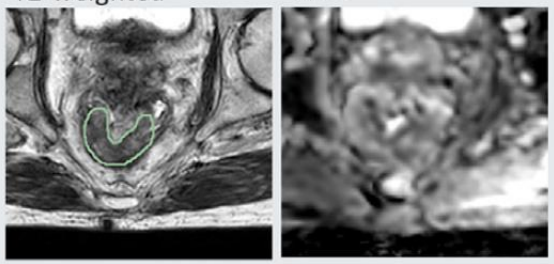
Pretreatment images of complete responder

T2-weighted ADC



Pretreatment images of partial responder

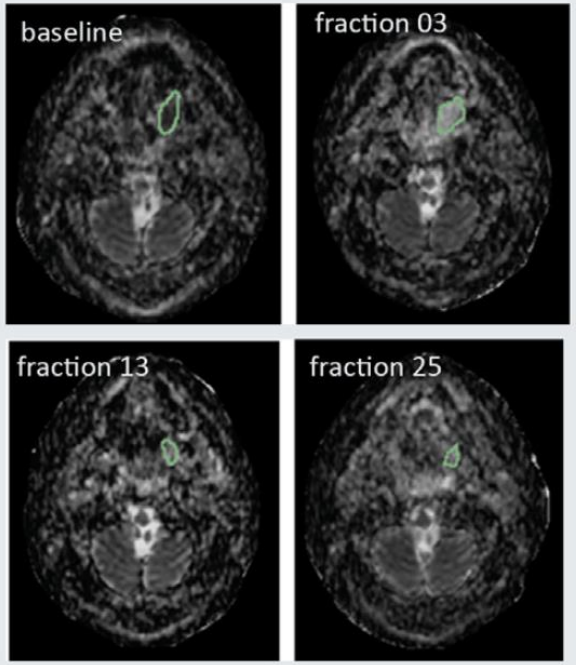
T2-weighted ADC

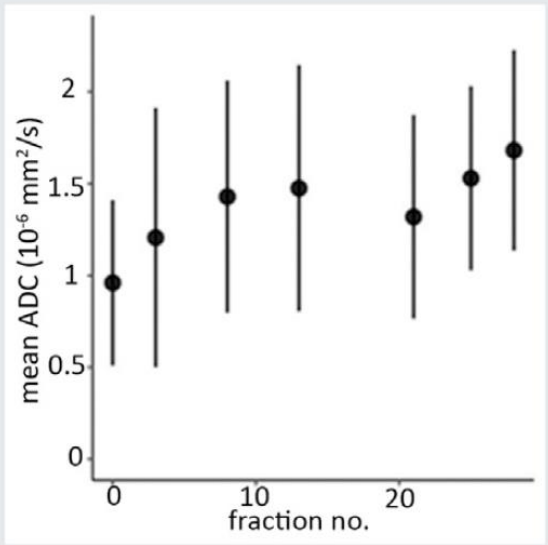


During treatment

Modify the dose and/or dose distribution

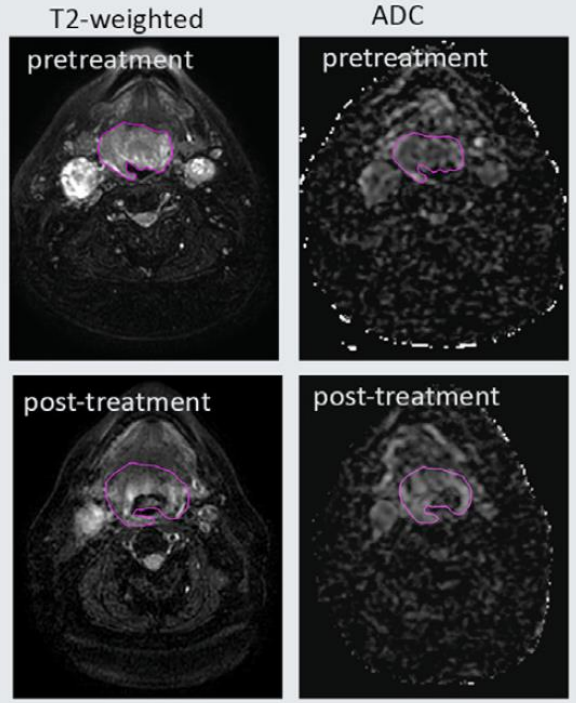
ADC





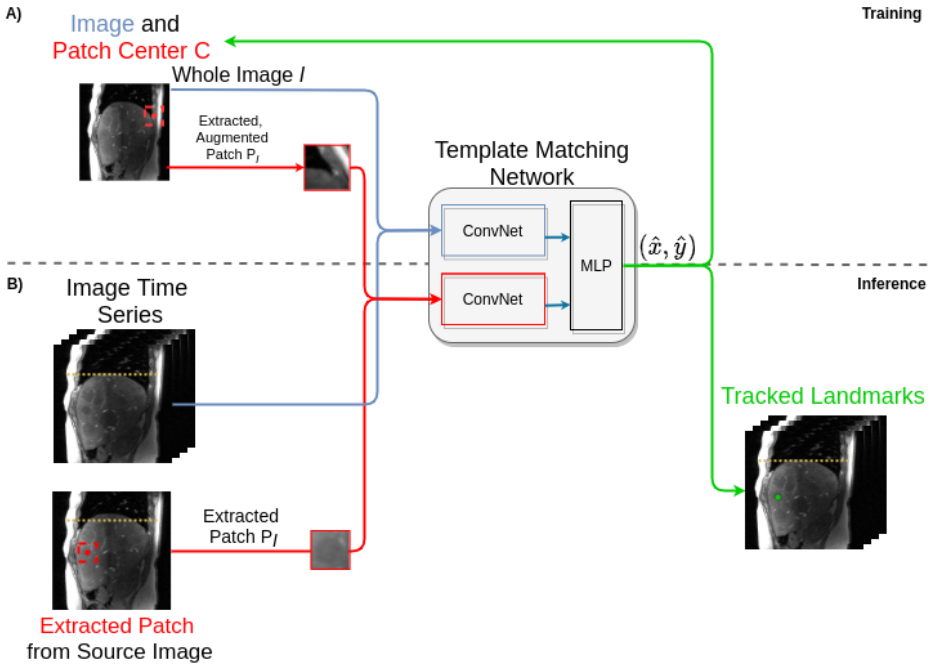
Post-treatment

Determine next steps in treatment

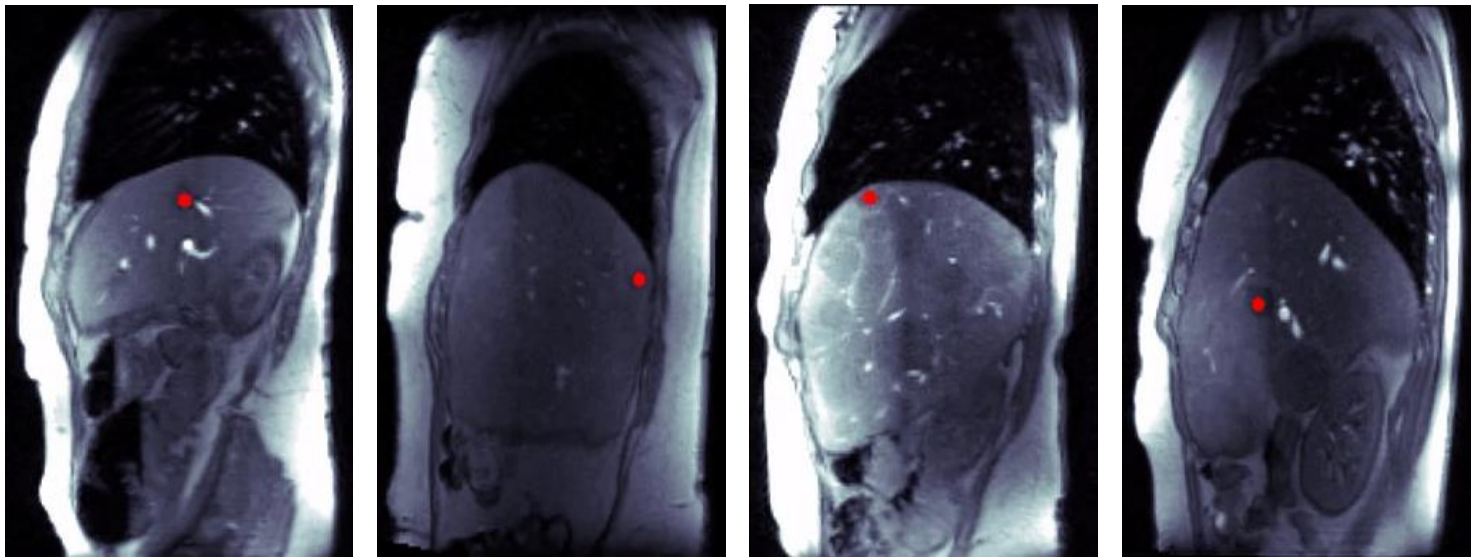


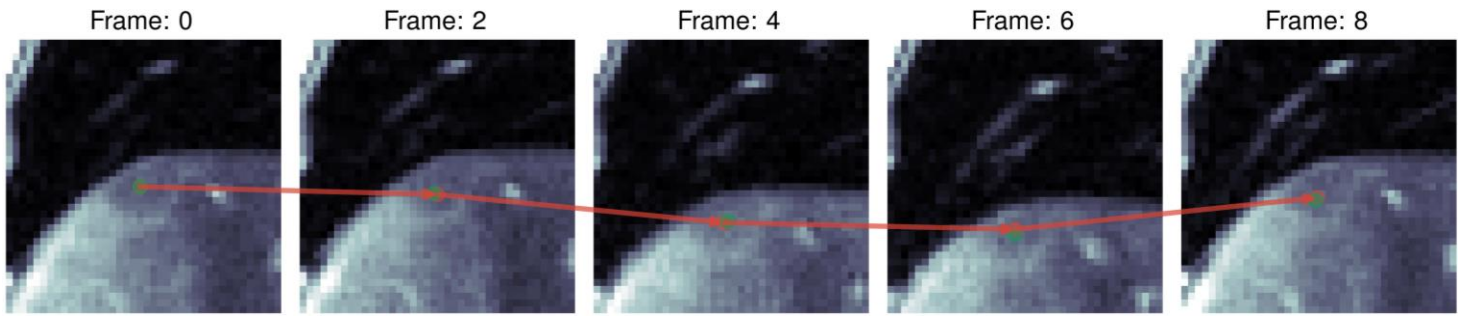
van Houdt P, Thorwarth D., et al., European Journal of Cancer 153 (2021) 64e71

Real-time lesion tracking & Motion correction during interventions



Real-time tracking of liver metastasis

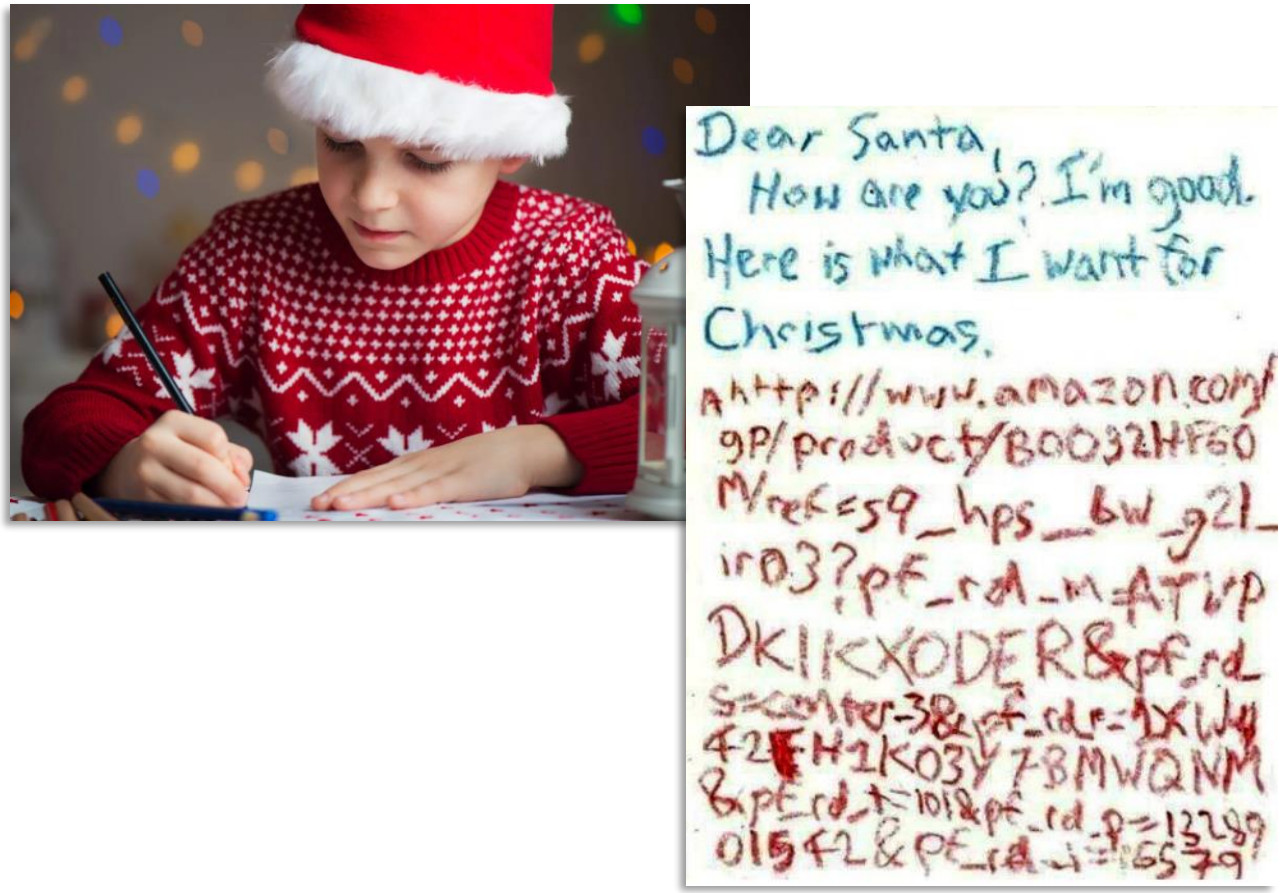




Inference < 10 ms

Früh M., et al, *IEEE Access* 2022

Wishlist – Where do we go from here with MRI?



- Make it fast
- Make it easy
- Make it affordable
- Make it available
- Make it valuable

… Let it still be fun!

Future of MRI:
Work *Smarter*,
not *Harder*!

Thank you!

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