2024 Midwest Radiation Oncology Symposium

Use of AI to Improve Access to Radiotherapy in Low and Middle-Income Countries (LMICs)

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THE UNIVERSITY OF TEXAS
MD Anderson Cancer Center
Making Cancer History®

Disclosures

Some of the slides were provided by Laurence Court, the creator of the RPA.

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- Linda Wells Outreach Award

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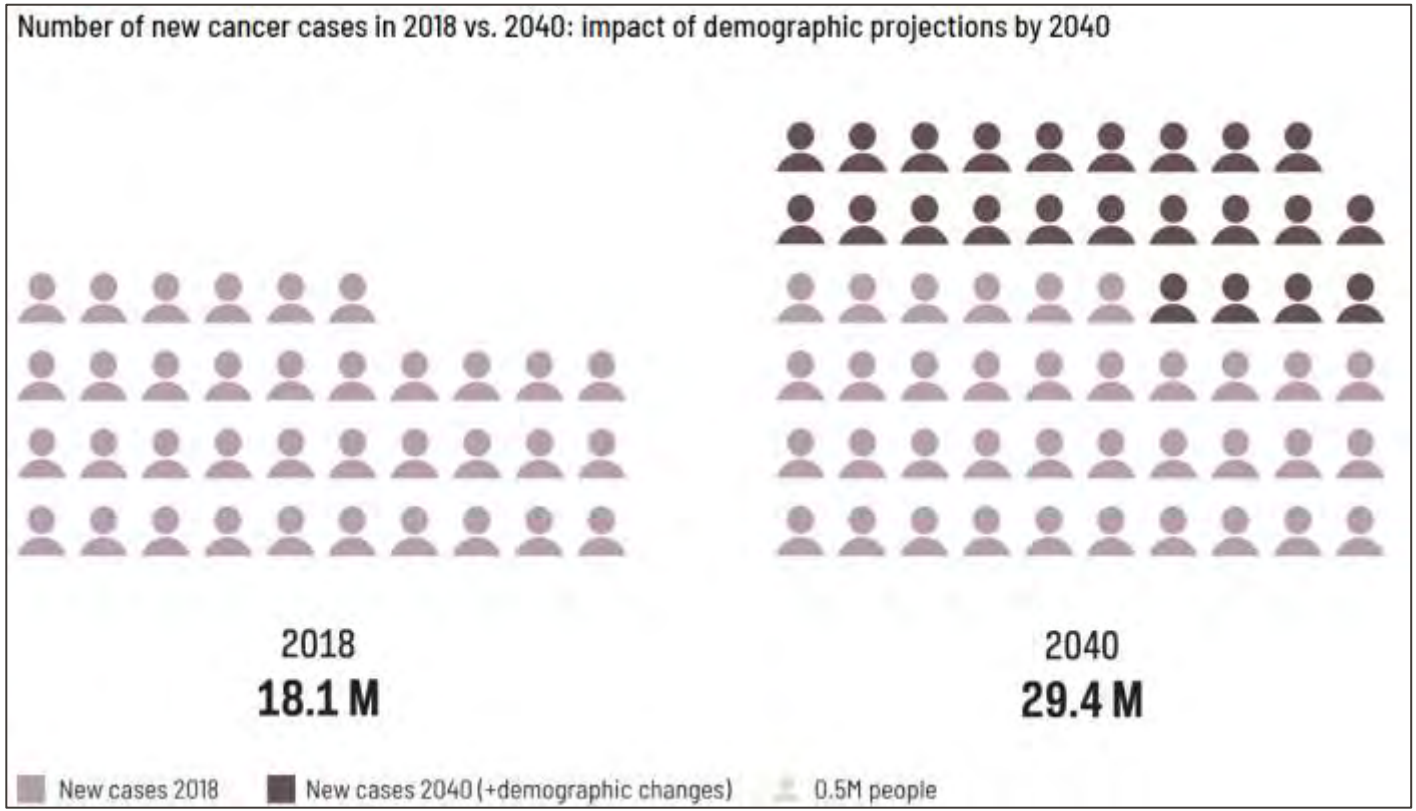
- National Cancer Institute
- Wellcome Trust
- Cancer Prevention & Research Institution of Texas (CPRIT)
- Fund for Innovation in Cancer Informatics
- Varian Medical Systems
- University of Texas MD Anderson Cancer Center

Cancer Burden

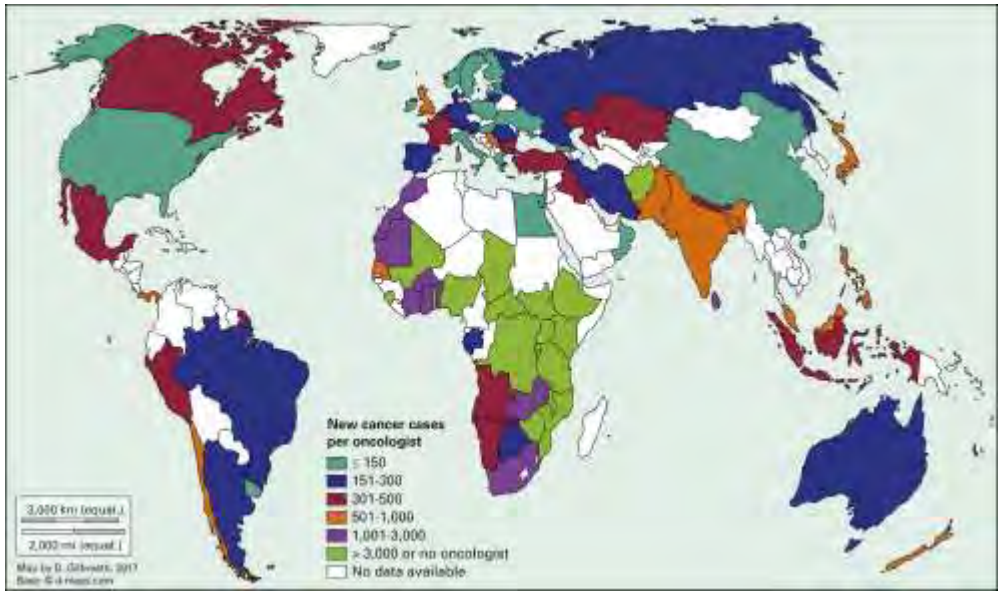


THE CANCER ATLAS

Global Workforce Shortage

- Supply of radiation oncologists is expected to fall short of demand[1]
- The situation will be far worse in low-middle income countries where the ratio of patient to oncologists is already extremely high[2]
- 1,000 patients for every 1 oncologist in LMICs compared to 150 patients for every 1 oncologist in developing countries

Figure– Availability of oncologists worldwide[2]



1.Yang W, Williams JH, Hogan PF, et al. Projected supply of and demand for oncologists and radiation oncologists through 2025: an aging, better-insured population will result in shortage. *J Oncol Pract*. 2014;10(1):39-45.

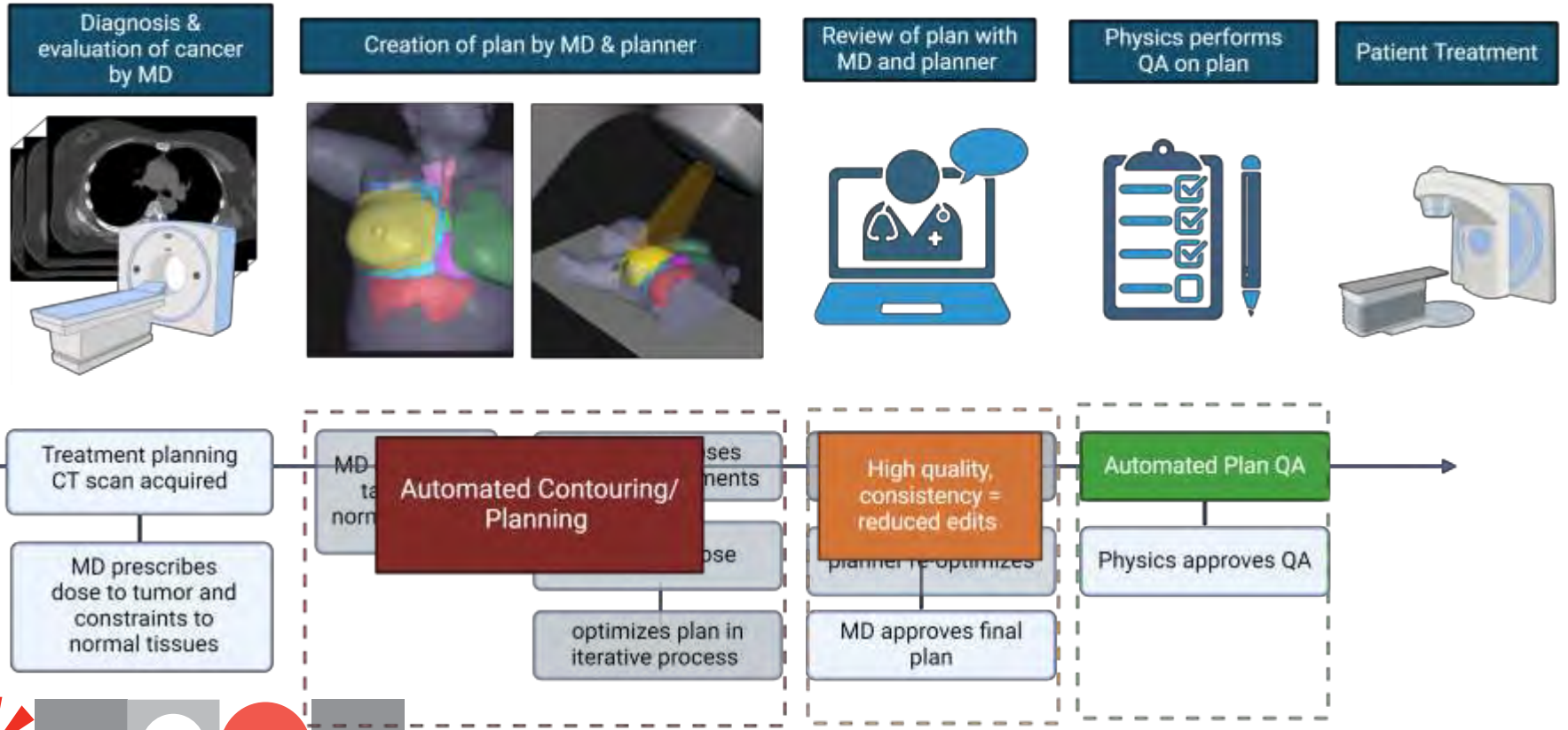
2.Mathew A. Global Survey of Clinical Oncology Workforce. *J Glob Oncol*. 2018;(4):1-12.

The Issue

- Increase in number of patients + shortage in workforce → Treatment delays
- Hanna et al. conducted a systematic review across the seven most common cancers based on 34 studies. Their work indicated that even a four-week delay in commencing cancer treatment could impact survival.*
- 9% increased risk of death for 4-week delay in head and neck radiotherapy

Hanna et al. 2020

Potential Use of AI in Radiotherapy



Potential Benefits of AI in Radiotherapy

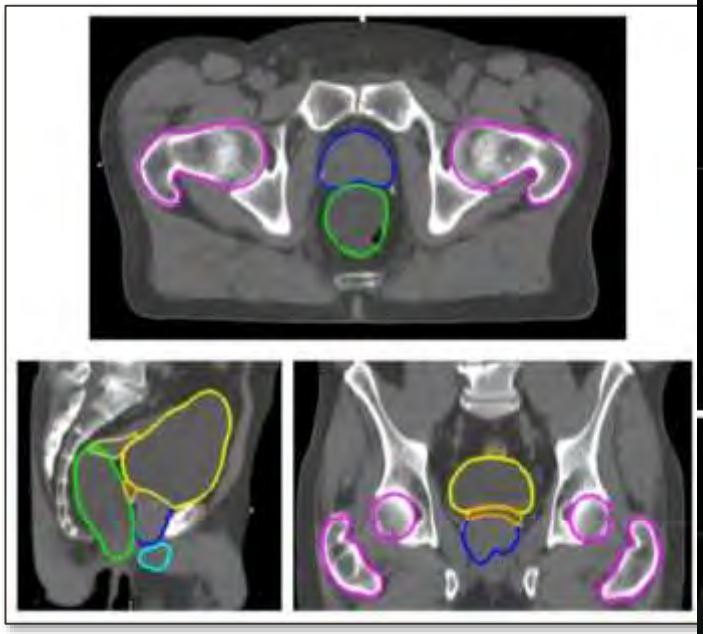
- **Gains in efficiency (per patient):**
  - Up to 2-3 hours of physician's time
  - Up to 4 hours of treatment planner's time
  - Reduced hand-offs -> significant reduction in time
- **Gains in quality and safety of radiation treatments:**
  - Improved consistency of treatments between institutions
  - Improved quality of treatments (in many cases)
  - Reduced hand-offs -> reduced risk
- **Gains in consistency gives many other benefits for data analysis:**
  - Treatment response
  - Toxicity
  - Radiomics

- Web-based platform that offers high-quality automated contouring and planning across the world, free of charge.
- The RPA has received 510(k) clearance in 2023 (not marketed in the USA) and is launched in South Africa in the first quarter of 2024.

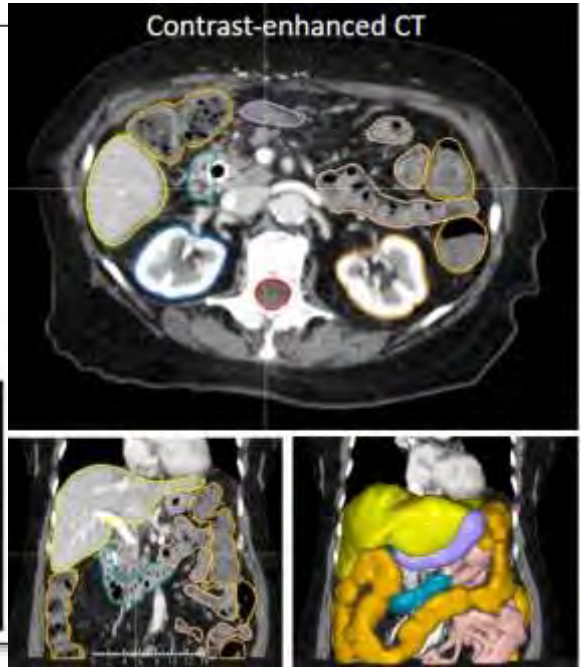
Automated Contouring

High Quality Automated Contouring

- H&N Normal Tissues
- H&N CTVs
- Cervix CTVS
- Cervix Normal Tissues
- Upper Abdomen
- Vertebral Bodies
- Thoracic Normal Tissues
- Prostate CTVS & Normal Tissues
- Breast



Daniel El Basha



Cenji Yu

Clinical acceptability

H&N normal tissues:

- 75 reviews, 4 radiation oncologists, 3 centers
- Parotid: 96% use as is, 100% after minor edits
- Submandibular gland: 77% use as is, 91% after minor edits

H&N CTVs

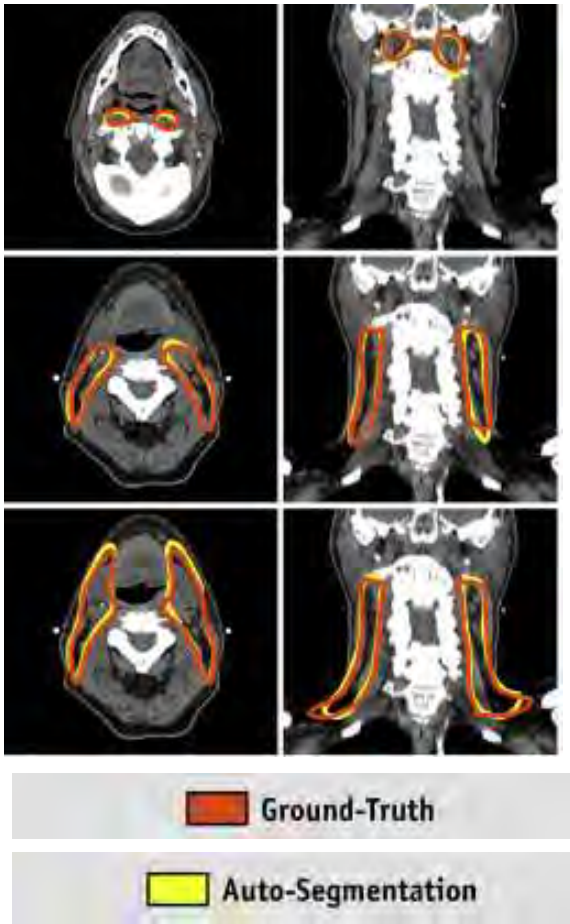
- 94 reviews, 3 radiation oncologists, 3 centers
- CTVs: 12-96% use as is, 97%-100% after minor edits

Cervix

- 30 reviews, 1 radiation oncologist, 1 center
- Primary CTV: 83% use as is
- Rectum: 93% use as is

Upper abdomen

- 75 reviews, 5 radiation oncologists, 3 centers
- Duodenum: 60% use as is, 89% after minor edits
- Liver: 84% use as is, 97% after minor edits



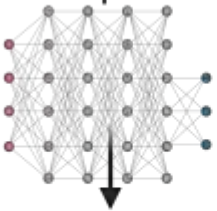
Specific Example- Breast Targets Automated Contouring

A. Model Creation

104 WB CT Scans with contours

+

nn-Unet deep learning model



2 Breast Automated Contouring model (Left & Right)

B. Model Validation

21 patients used for testing

Quantitative:	Qualitative:
DSC=2x 	Physician Score Automated contour:
MSD~surface variation	5: Use As is 4: Minor Edits Not Necessary 3: Necessary Minor Edits 2: Major edits 1:Unusable

Baroudi et al. 2023

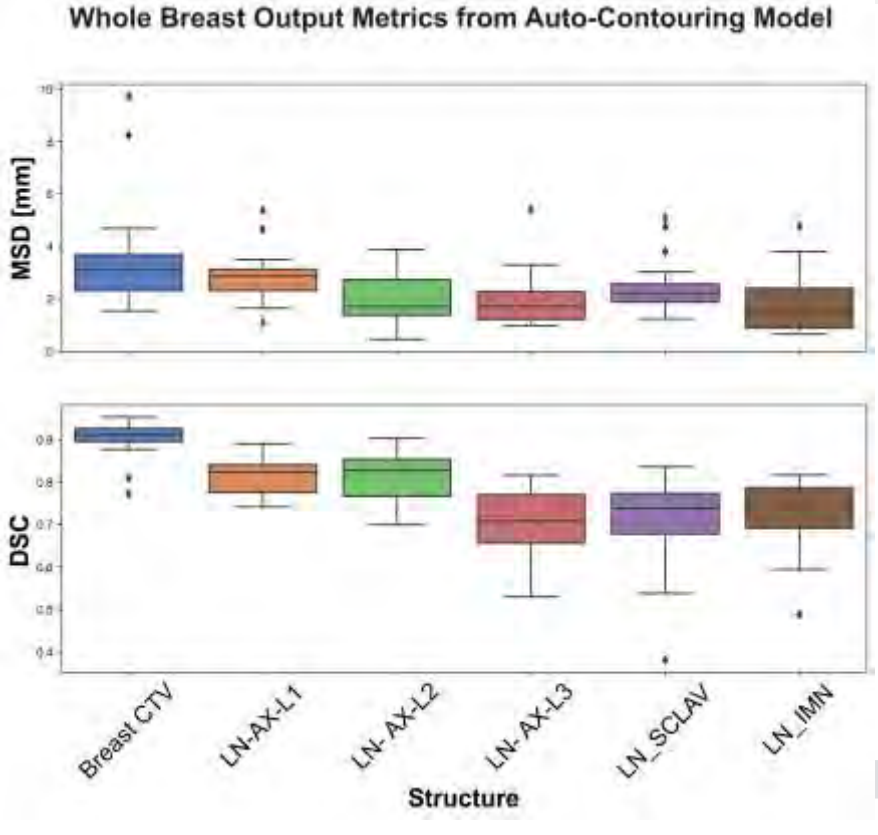
Model Evaluation

Breast contour and regional lymph nodes:

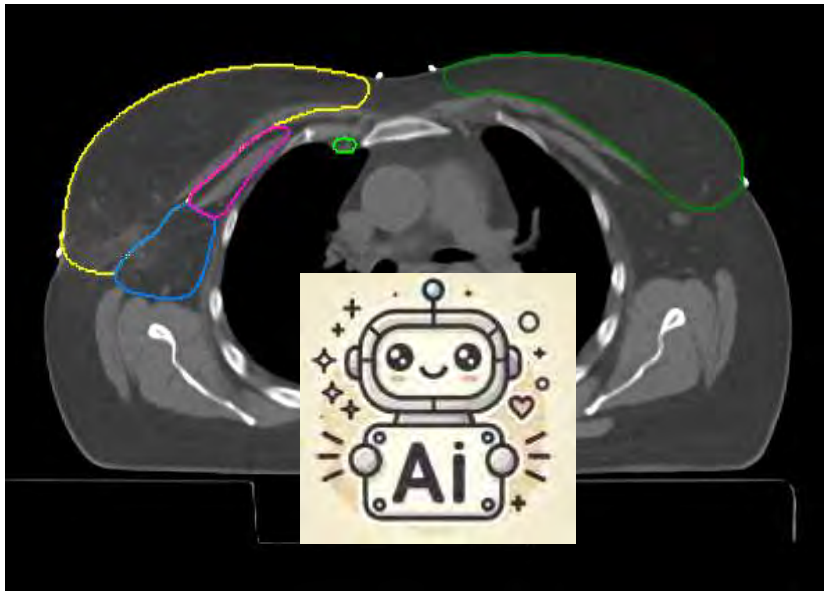
- mean DSC values >0.7
- mean MSD <3 mm

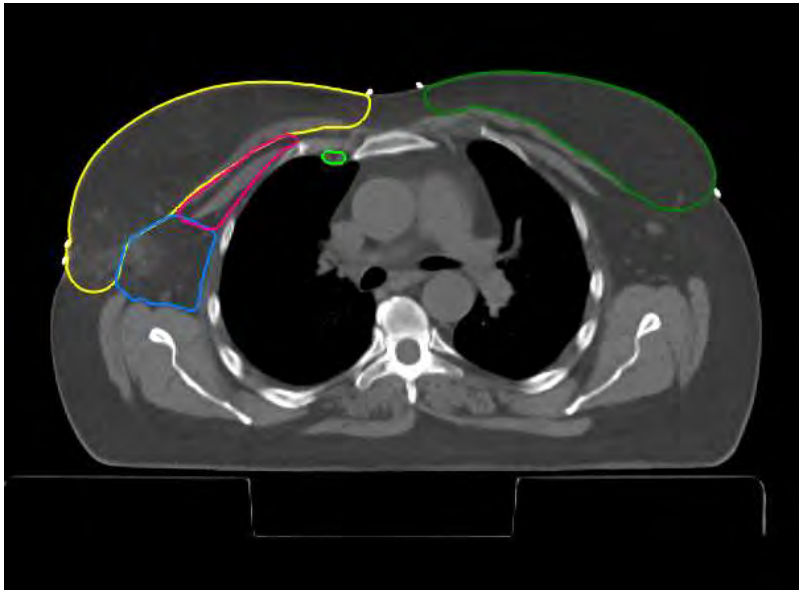
Two Physicians reviewed and scored all contours as **clinically acceptable** (score >= 3)

- Physician1 scoring 58%/41% of the contours as use-as-is/requiring minor edits
- Physician2 scoring them as 59%/40%.



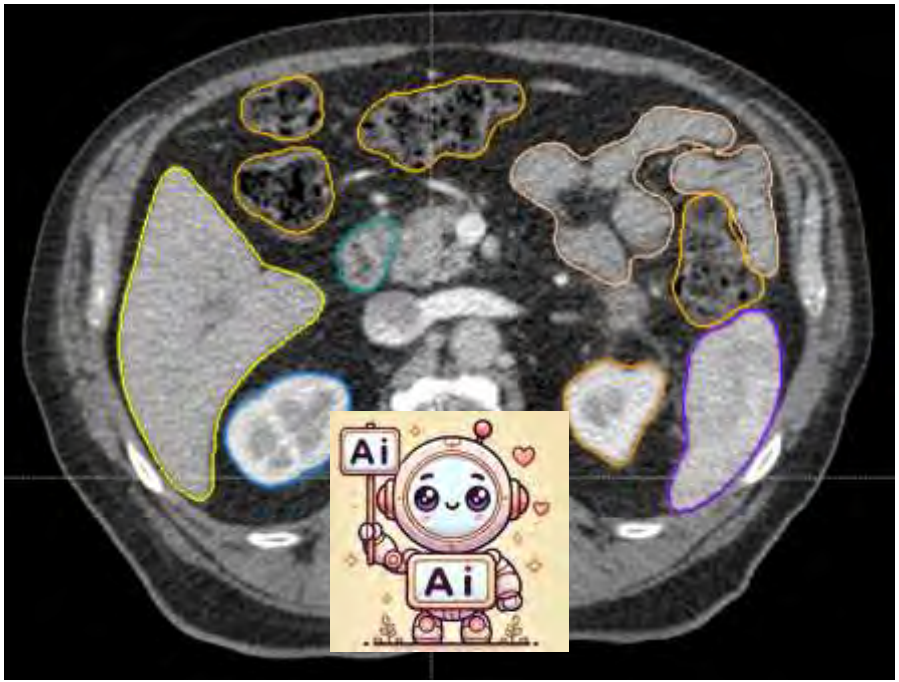
Which were AI generated? (Breast Example)





**Robot Image generated with Chatgpt*

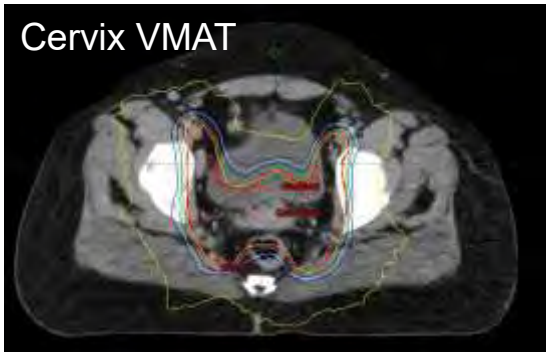
Which were AI generated? (GI Example)



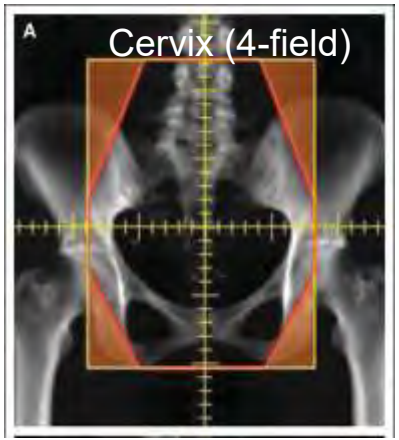
**Robot Image generated with Chatgpt*

Automated Planning

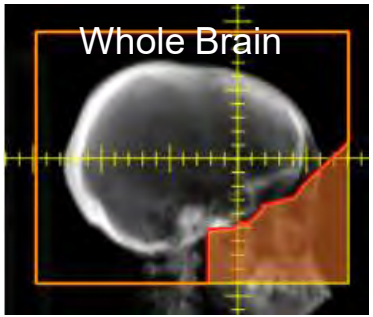
RPA Automated Planning



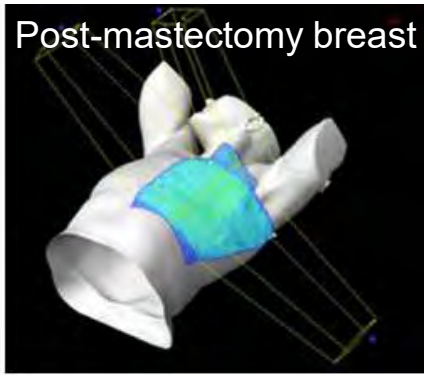
DJ Rhee, Med Phys 2022



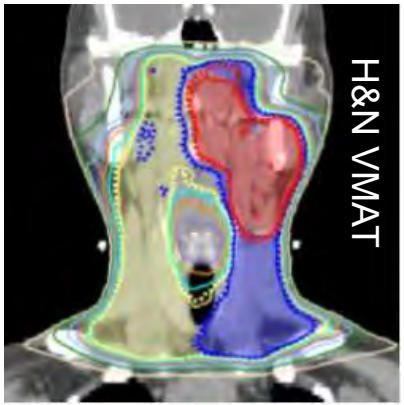
Kisling JGO 2019



Xiao, ROP 2022

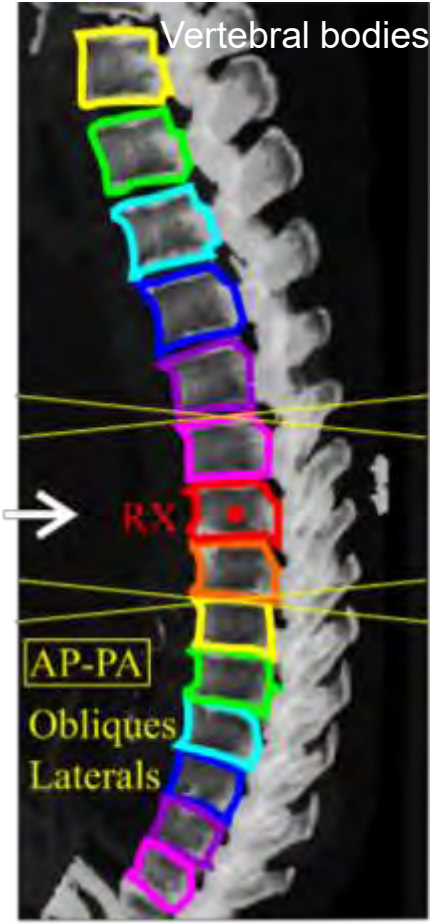


Kisling Med Phys 2019



Olanrewaju PRO 2021

Hernandez PBC 2023



Netherton, IROBP 2022

Clinical Acceptability of Autoplans

H&N VMAT

- 60 reviews, 14 radiation oncologists, 14 centers
- 88% use as is (compare with 78% when blindly reviewing clinical plans)

Cervix simple plans (4-field box)

- 70 reviews, 2 radiation oncologists, 2 centers
- 87% use as is, 97% after minor edits

Cervix VMAT

- 70 reviews, 2 radiation oncologists, 2 centers
- 94% use as is

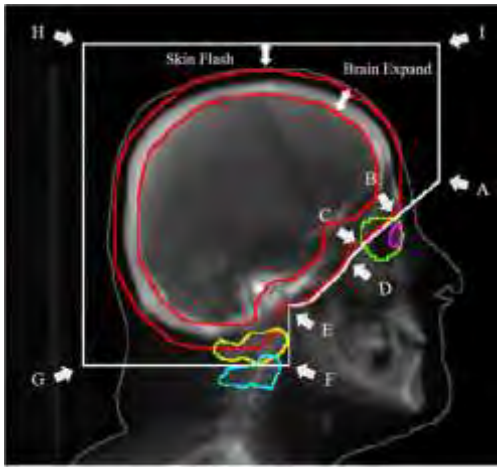
Whole brain

- 75 reviews, 5 radiation oncologists, 5 centers
- 92% acceptable after minor edits

- Independent review at Ocean Road Cancer Institute, Tanzania
  - Cervix soft-tissue 4-field box
  - 60 reviews, 2 radiation oncologists
  - **100% use as is**

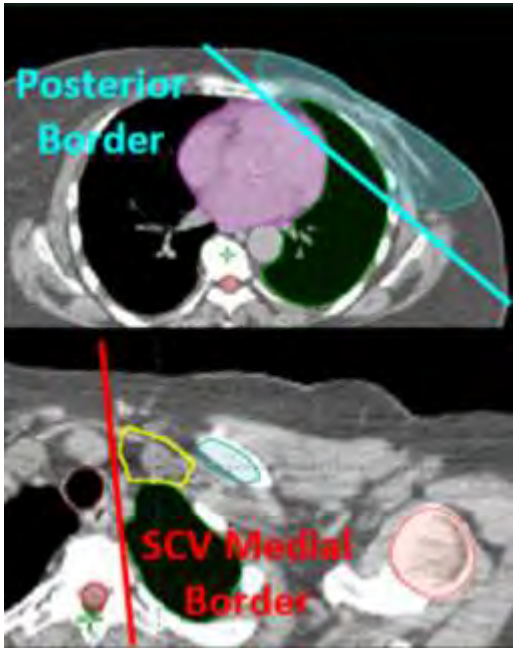
Automated Planning Methodologies

Rule Based Planning



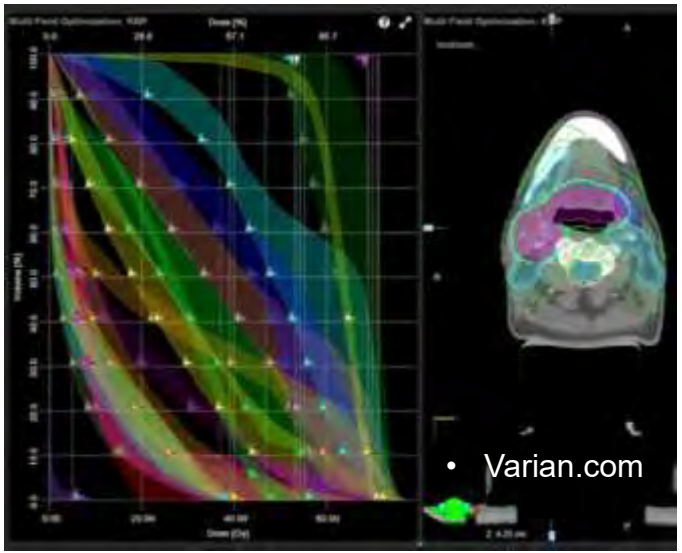
Determining field shape for whole brain treatments using landmarks (A-I)

Machine learning Based



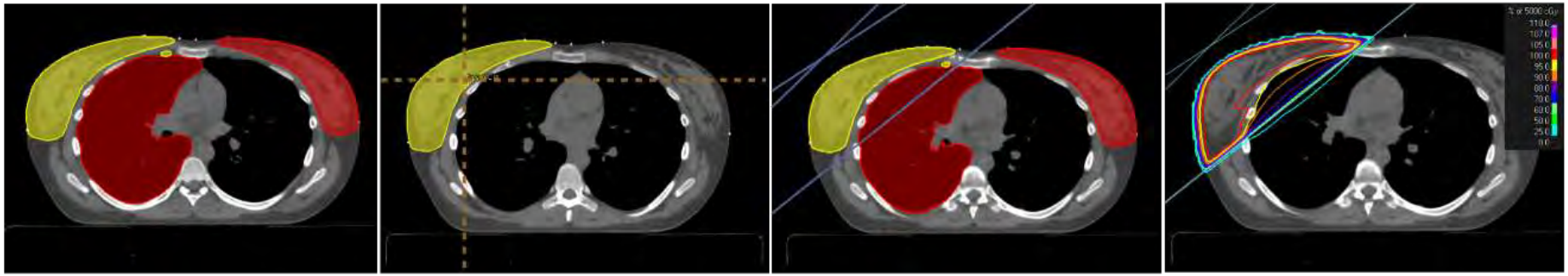
support vector machine to determine treatment borders

Knowledge Based Planning (RapidPlan)



Predictive model relaying anatomical structures to dose distributions to generate and optimize VMAT plans

Specific example- Intact Breast Automated planning Algorithm Methodology



Contouring → Isocenter Setup → Beam Setup → Dose Optimization

Autocontours generated from nnUnet deep learning model

Isocenters automatically set based on auto-contours

Rule Based Planning for determining gantry angles. Apertures based on contours

Patient based weighing of fields with an auto FIF approach for tangents.

Unpublished work

Algorithm Development Methodology

- **Shadow Dosimetrist**
- **Focus groups with physicians and physicists to get a consensus about acceptable ranges of values (beam angles, size of regions of avoidance…)**
- **Algorithm initial development**
- **Testing on cases of different breast sizes, arm positions, treatment sides, FB/BH…**
- **Optimize algorithm**
- **Final testing – 15 patients**
  - Dosimetric Validation
  - Physician Review
- **Validation focus groups (physics, dosimetry)**
- **External Dataset Validation – 4 institutions worldwide, 40 cases total**

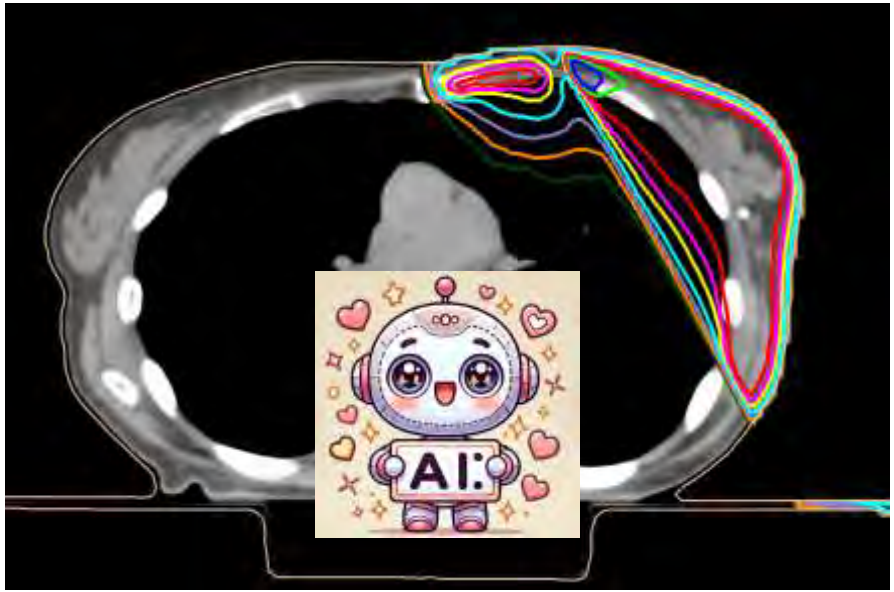
Which were AI generated?

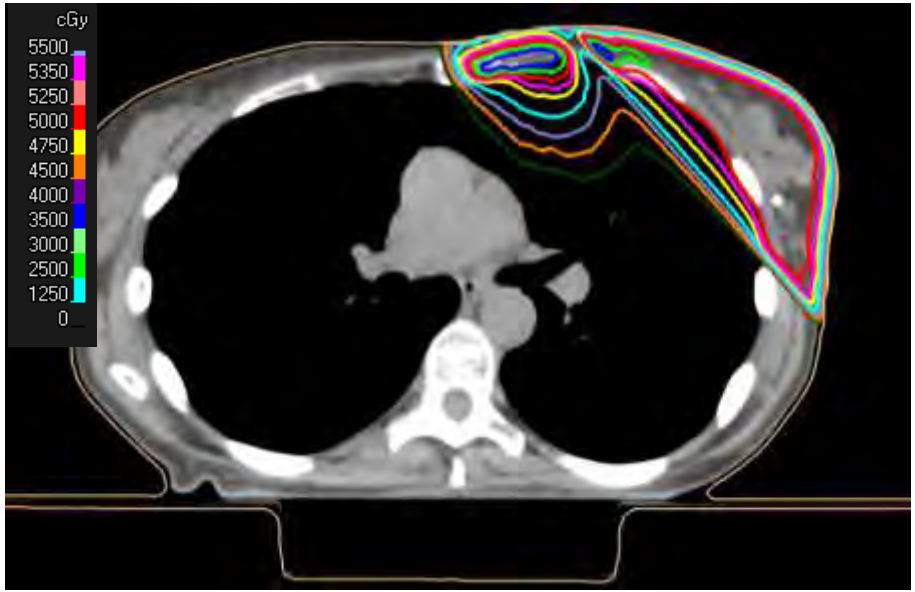
Partial Wide Tangent fields

**Robot Image generated with Chatgpt*

Which were AI generated?

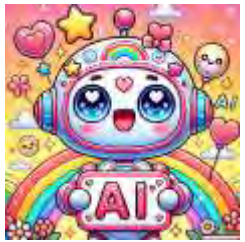
Breast tangents fields with adjacent electron field for IMN treatment

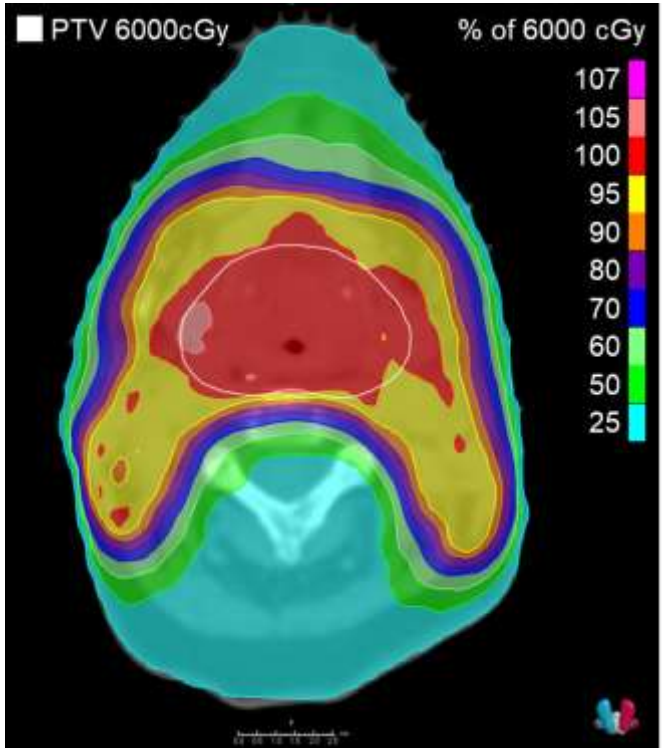


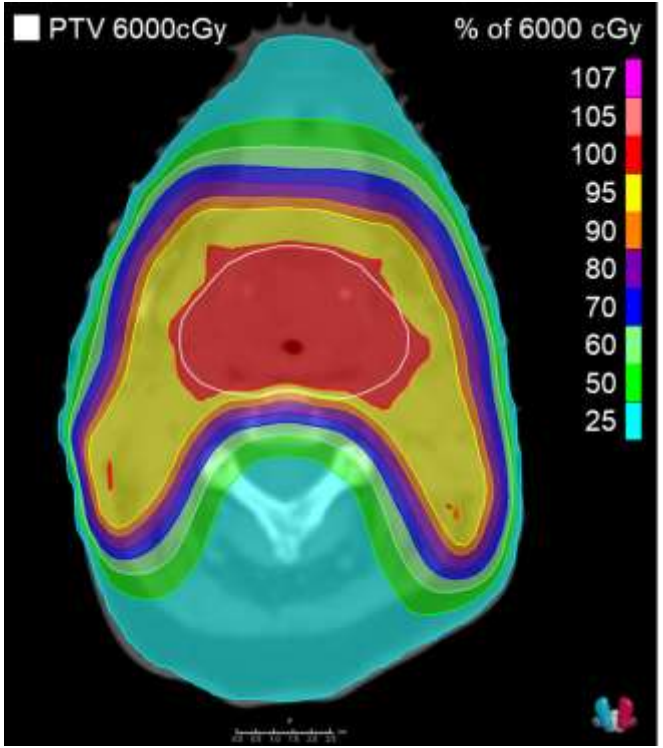


**Robot Image generated with Chatgpt*

Which were AI generated?



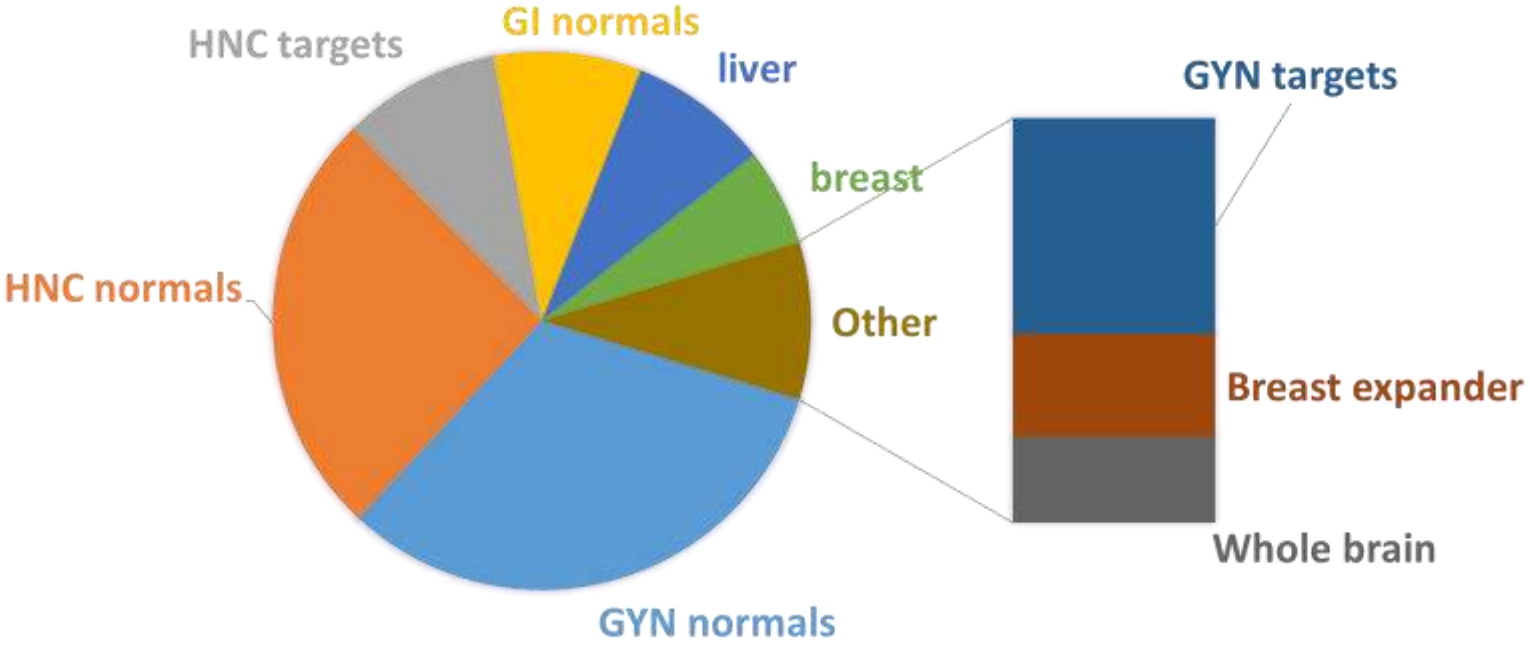




Robot Image generated with Chatgpt

Automated Tools Use at MD Anderson

Total use since deployment in 2020: **13,457** patients.
Time savings estimates: Total ~ 1500 Rad Onc h/yr

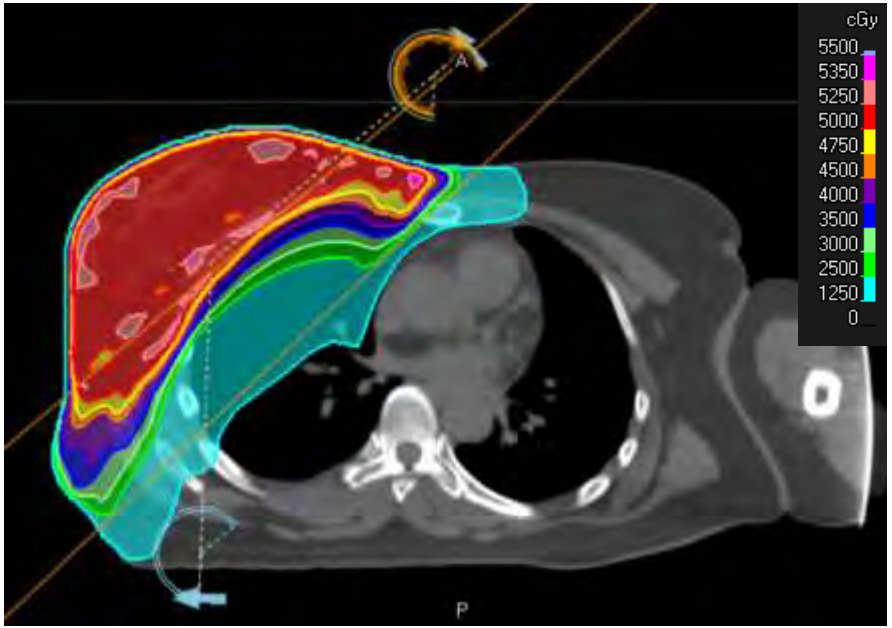


Fiandra et al. 2024

Real-World Application of Auto-planning

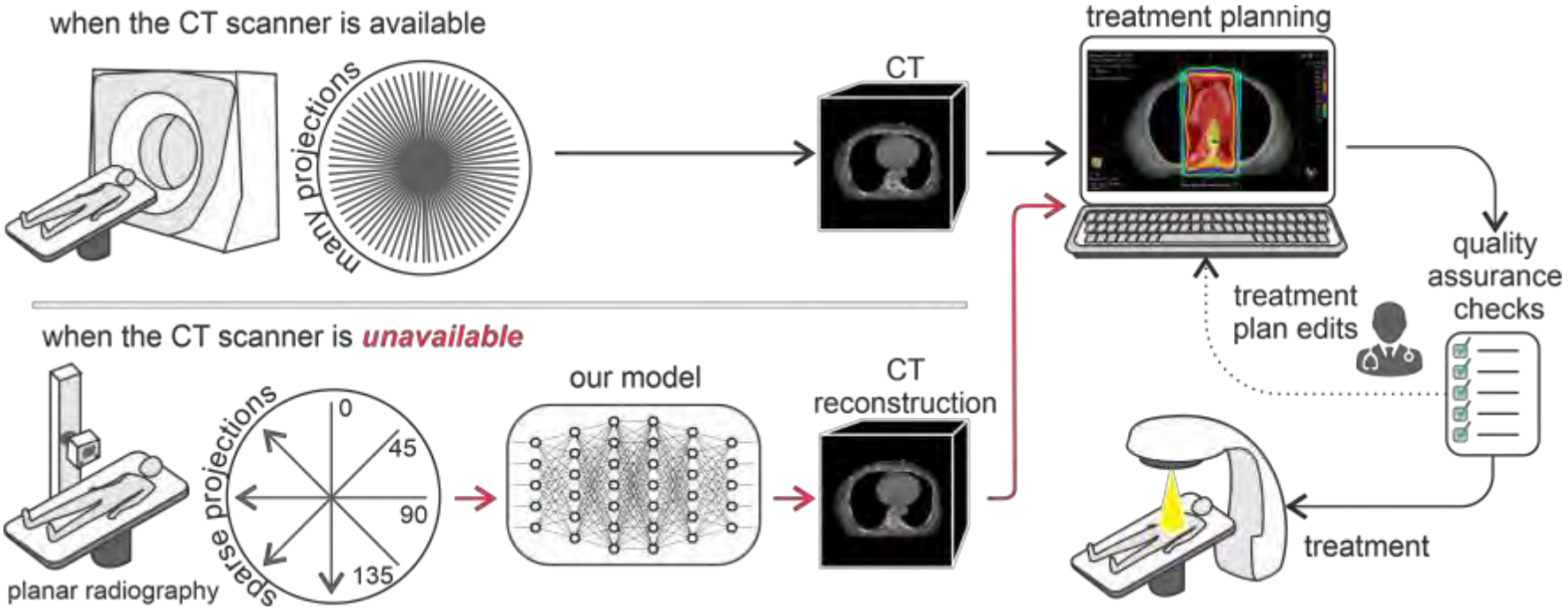
24 centers, 10 patients each, generated manual and automated IMRT/VMAT/Tomotherapy treatment plans for breast

- Quantitatively, auto-plans showed reduced Dmean for heart, ipsilateral lung and contralateral breast by 21.4%, 16.7% and 35.7%
- Qualitatively, clinicians preferred the auto-plan 49.6% of the times while manual plans were favored 40% and 10.4% of the time no preference was noted

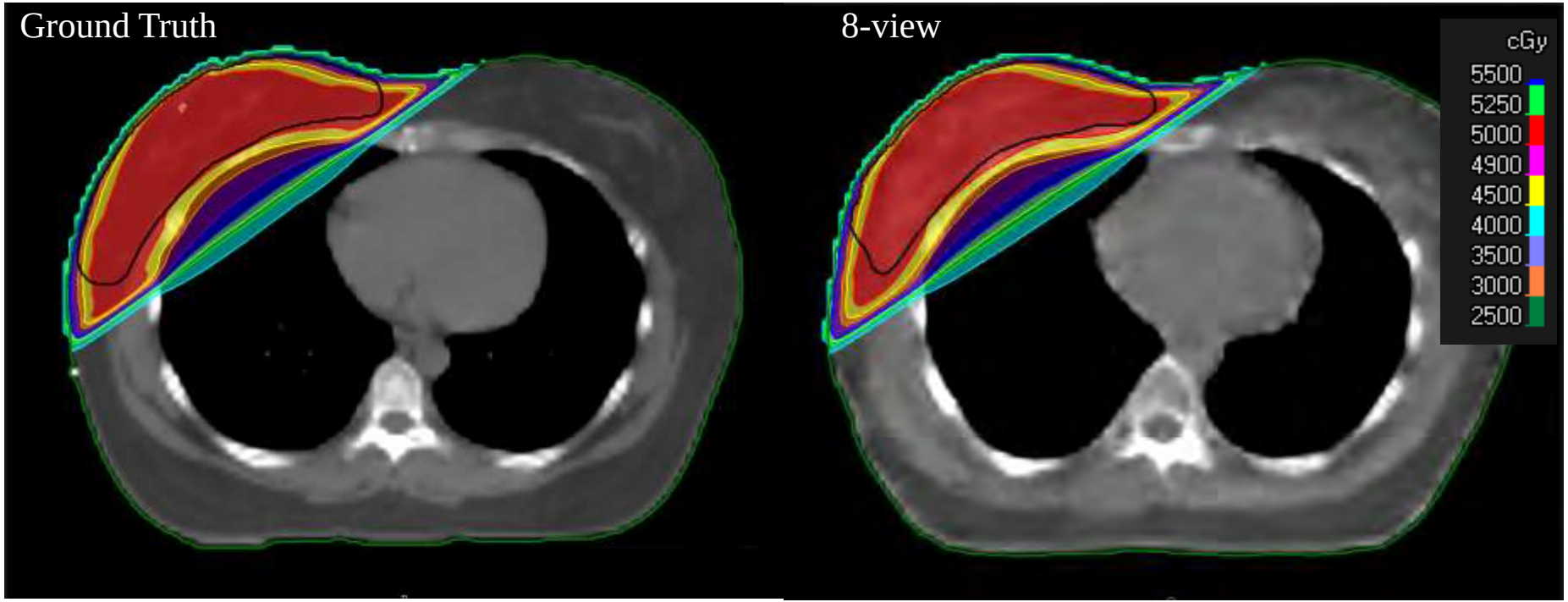


Dose distribution of in house RapidPlan VMAT plan

What if no CT scanners were available?



Unpublished work by Yiran Sun



Unpublished work

What about risk?

Implementation challenges

- Risk Assessment in clinical adoption of the RPA using FMEA
- Identified failure modes in each process steps
- Scored failure modes for
  - Occurrence, Detectability and Severity
  - A total risk priority number = O x D x S

Nealon et al. PRO 2022

Automated Quality Assurance

For automated treatment planning of cervix:
- **Automatic verification of the isocenter**
- **Automatic verification of beam apertures**

With QA program, the risk priority number of high severity failure modes was reduced

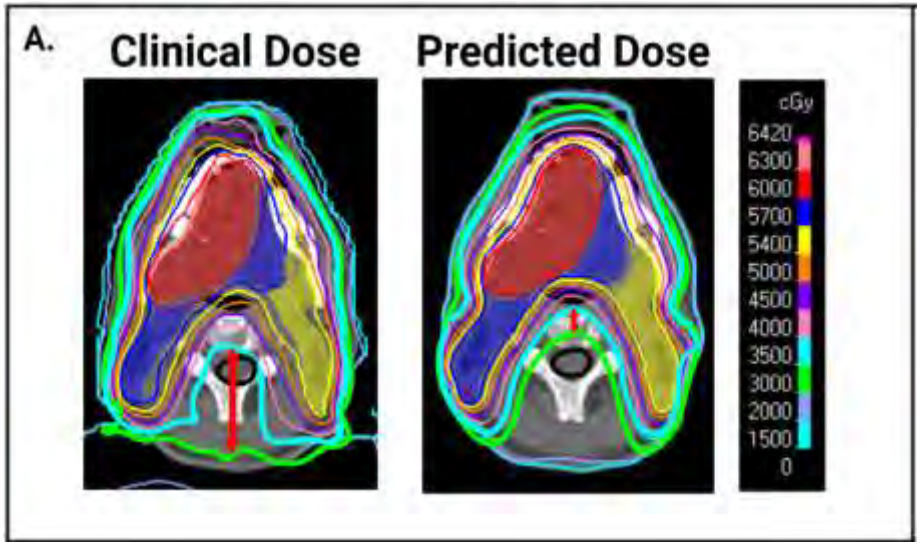
Kisling et al. Med Phys 2019

Automated Quality Assurance

Contour QA- use of secondary model

DJ Rhee, Med Phys 2019

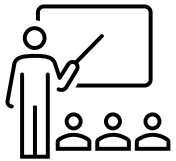
Plan QA- use of dose prediction



Gronberg, PRO 2024

Implementation Recommendations

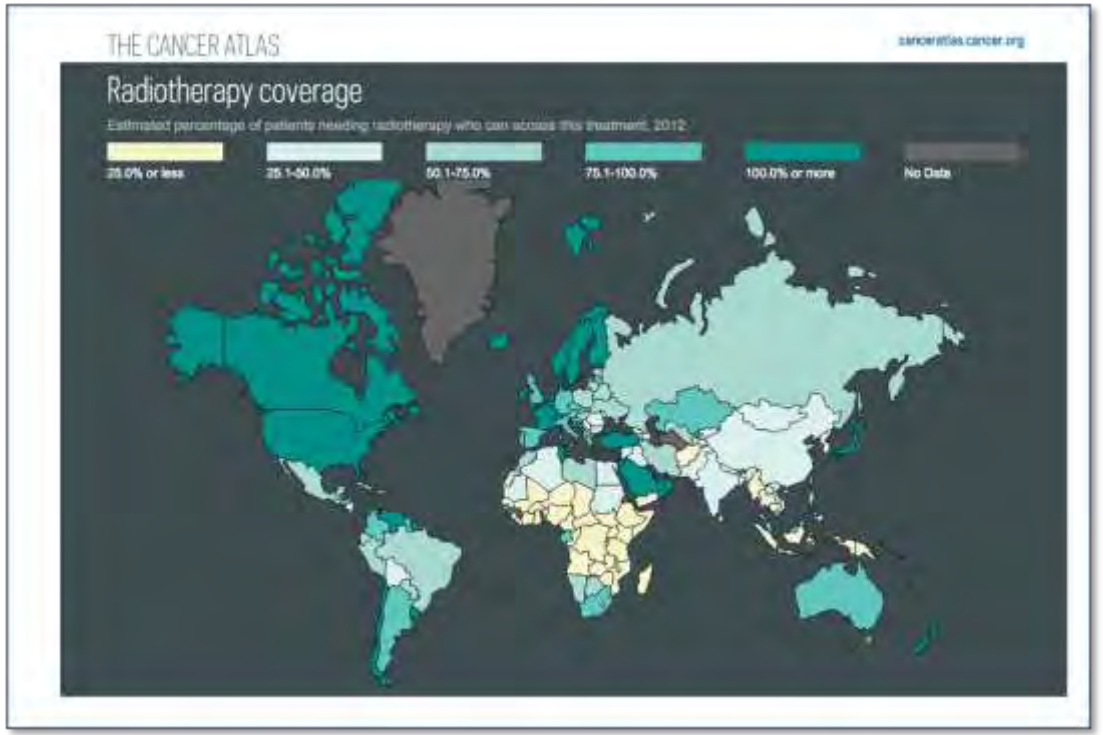
- **Manual Plan Checks**: Physician review of the uploaded CT scans, generated contours and autoplan is essential.
- **Education and Training**: Knowledge of the tools and the potential errors that could happen and their impact could help mitigate off-label use and automation bias.
- **Automated QA :** Automated checks could reduce errors.



Conclusions

How does AI improve access to radiotherapy in LMICS?

- Improved workflow
- Scale efforts – treat more patients
- Consistency
- Quality
- Plan QA/review
- Involvement in clinical trials
- Training



Acknowledgments

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RPA Project

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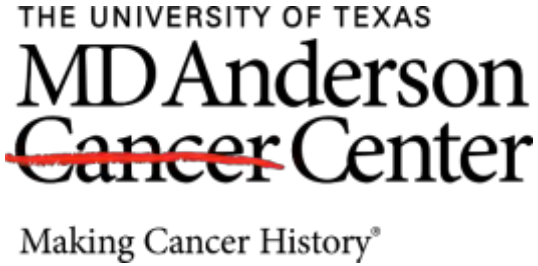
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