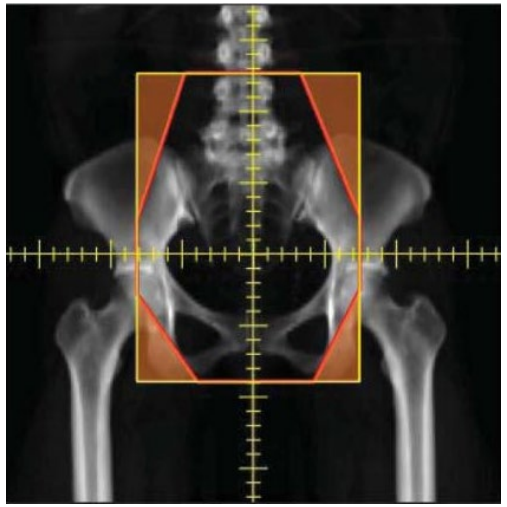
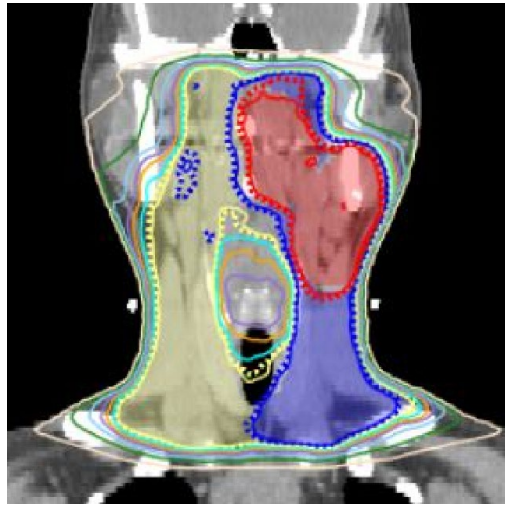


Radiation Planning Assistant



Automated Radiation Treatment Planning for Low- and Middle-Income Countries (LMICs)

16th Virtual Meeting of the National Cancer Advisory Board

Hannah Simonds, MD, PhD, *Tygerberg Hospital/Stellenbosch University, South Africa*

Beth Beadle, MD, PhD, *Stanford University, USA*

Laurence Court, PhD, *University of Texas MD Anderson Cancer Center, USA*

UH2/UH3:CA202665

Radiotherapy Resources in Africa

- As of March 2020:
  - Only 52% of African countries had access to external beam radiotherapy
  - Only 39% of African countries had access to brachytherapy
  - No country had capacity that met estimated need

- Acceptable practice 1 machine per 250,000 population -

- North and South Africa >50% of all RT machines

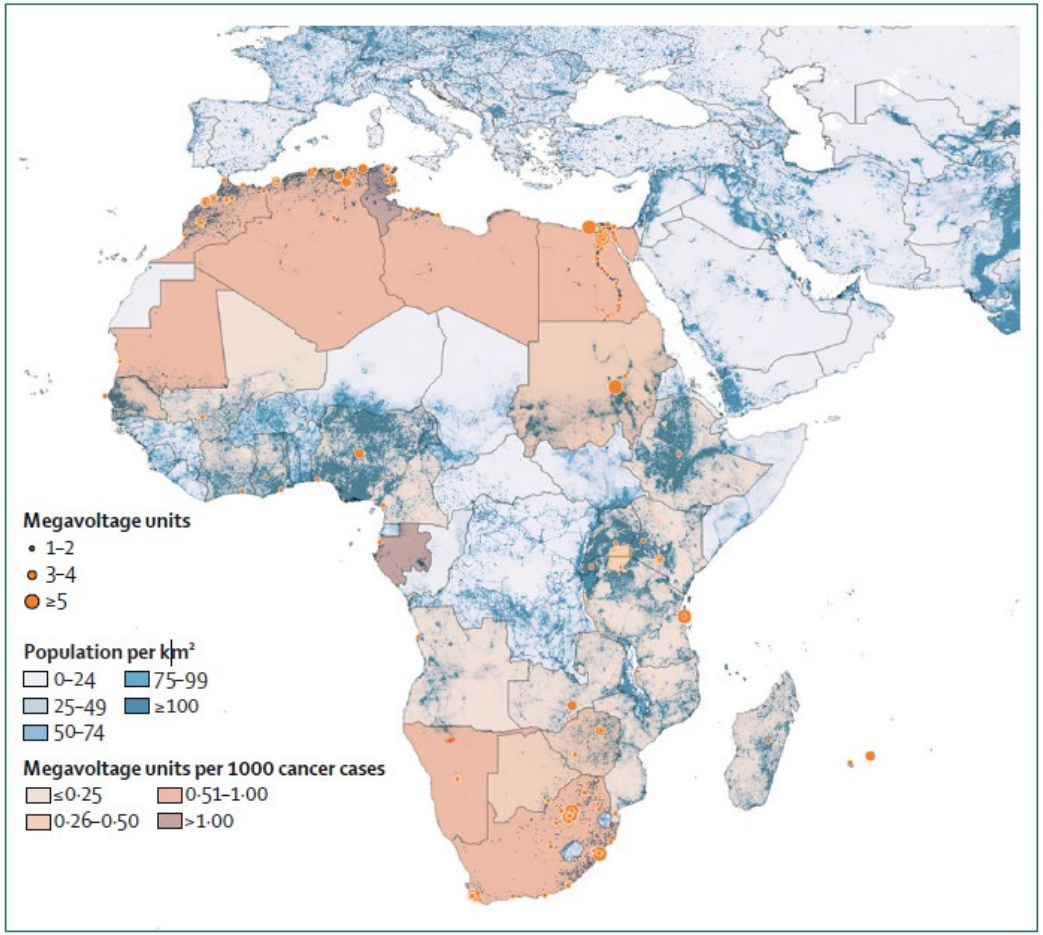
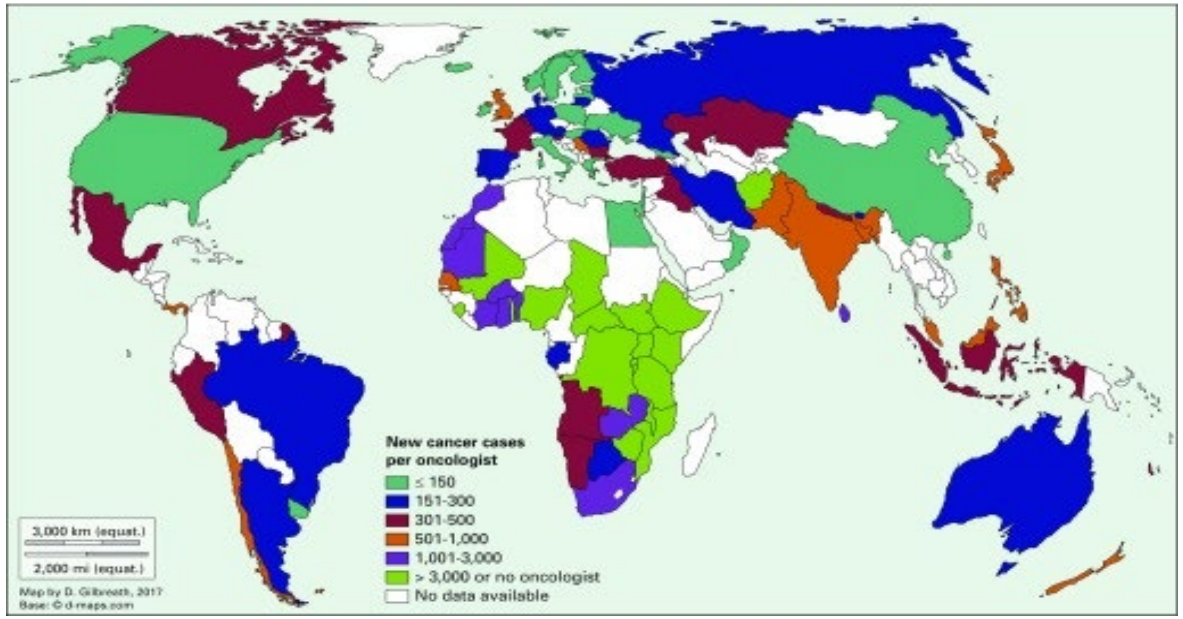


Figure 1: **External beam radiotherapy availability in Africa in 2020**
Blue layer represents population density. Orange dots represent radiotherapy centre locations, and size indicates megavoltage units per centre. Orange layer represents capacity in megavoltage units per 1000 cancer cases.

Elmore SK et al. Lancet Oncol 2021;22:e391-99.

But… Hardware does not fix access: Trained Personnel

- Clinical Oncologist Shortfall
  - 8 countries – no clinical oncologist.
  - 27 countries – a clinical oncologist provides care for >1000 incident cancers
    - 25 in Africa
    - 2 in Asia
    - None in Europe or Americas

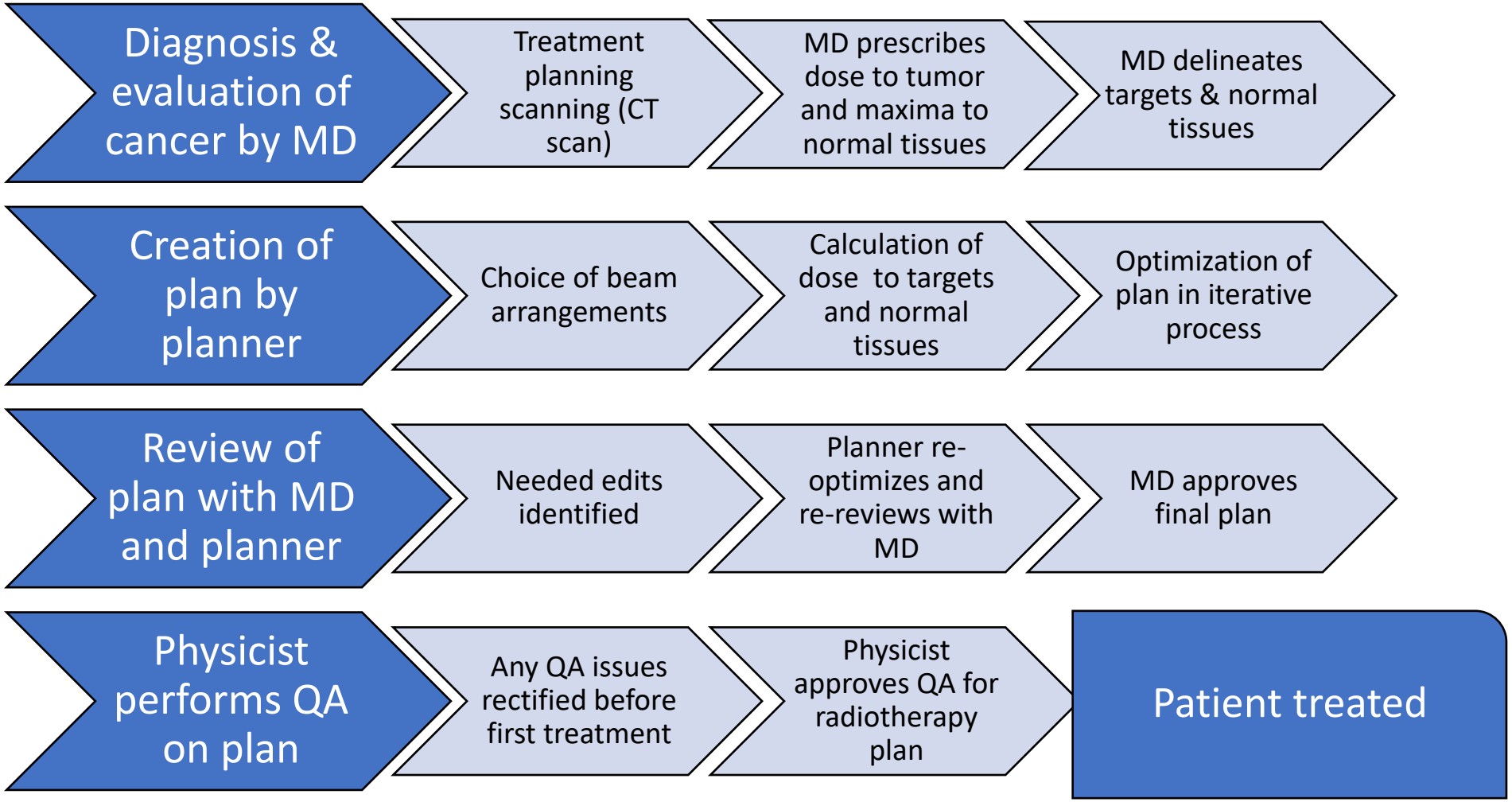


- Radiation Staff Shortfall
  - 23,000 radiation oncologists
  - 13,000 medical physicists
  - 39,000 radiation therapists/radiographers

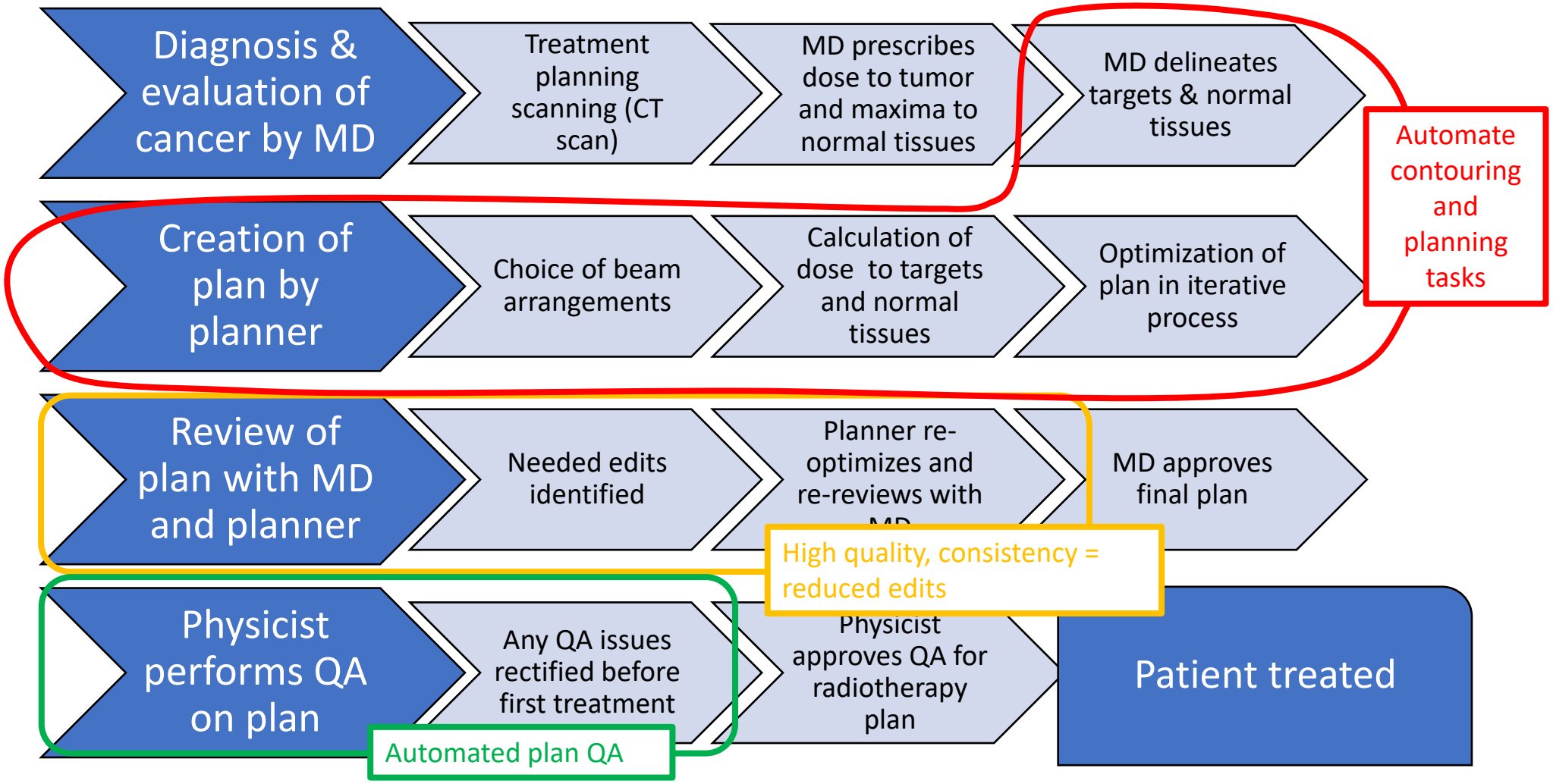
Infrastructure and personnel	No. of units or personnel/no. of patients (or range)*	No. of units or personnel/no. of patients used in this analysis	Present status (n=84 countries)		Required by 2020 (n=84 countries)	
			Existing/required	% of present deficit†	Total needed	% of additional required‡
Teletherapy units	1/450 patients	1/450 patients	4138/10,735	61.4%	13,307	+221.6%
Radiation oncologists	1/250-300 patients	1/250 patients	11,803/19,323	38.9%	23,952	+102.9%
Medical physicists	1/450-500 patients (3) 1/300-400 patients (17)	1/450 patients	3392/10,735	68.4%	13,307	+292.3%
Radiotherapy technologists	1/100-150 patients	1/150 patients	10,780/32,204	66.5%	39,920	+270.3%

Mathew A. JCO Global Oncology 2018;4:1-12.
Datta NR. IJROBP 2014;89(3):448-57.

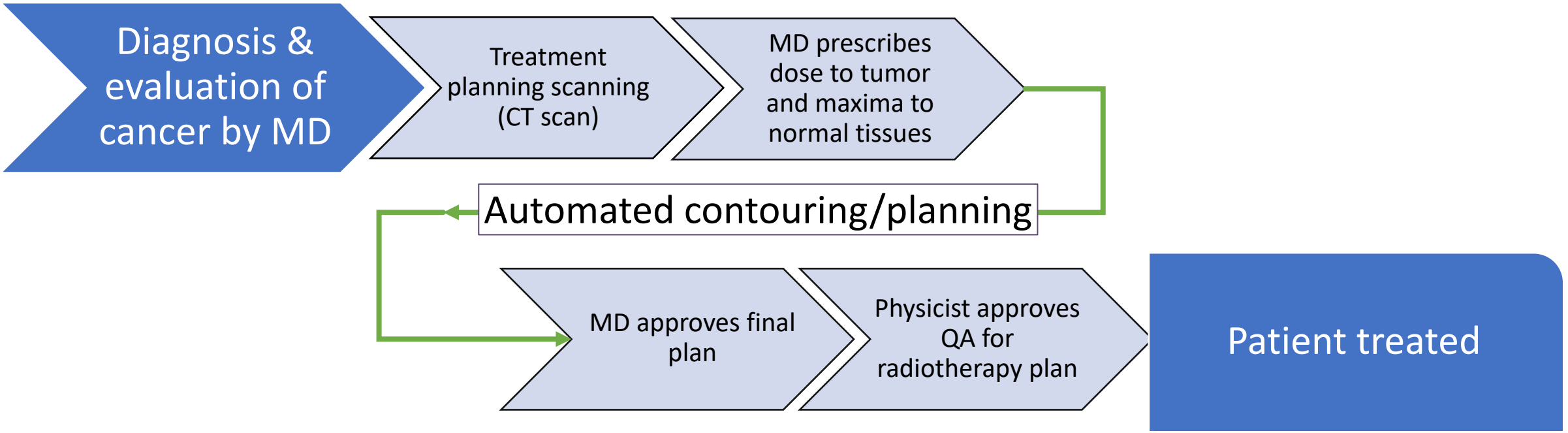
Complexity of Radiotherapy: Multiple Trained Personnel



Complexity of Radiotherapy: Potential for Automation



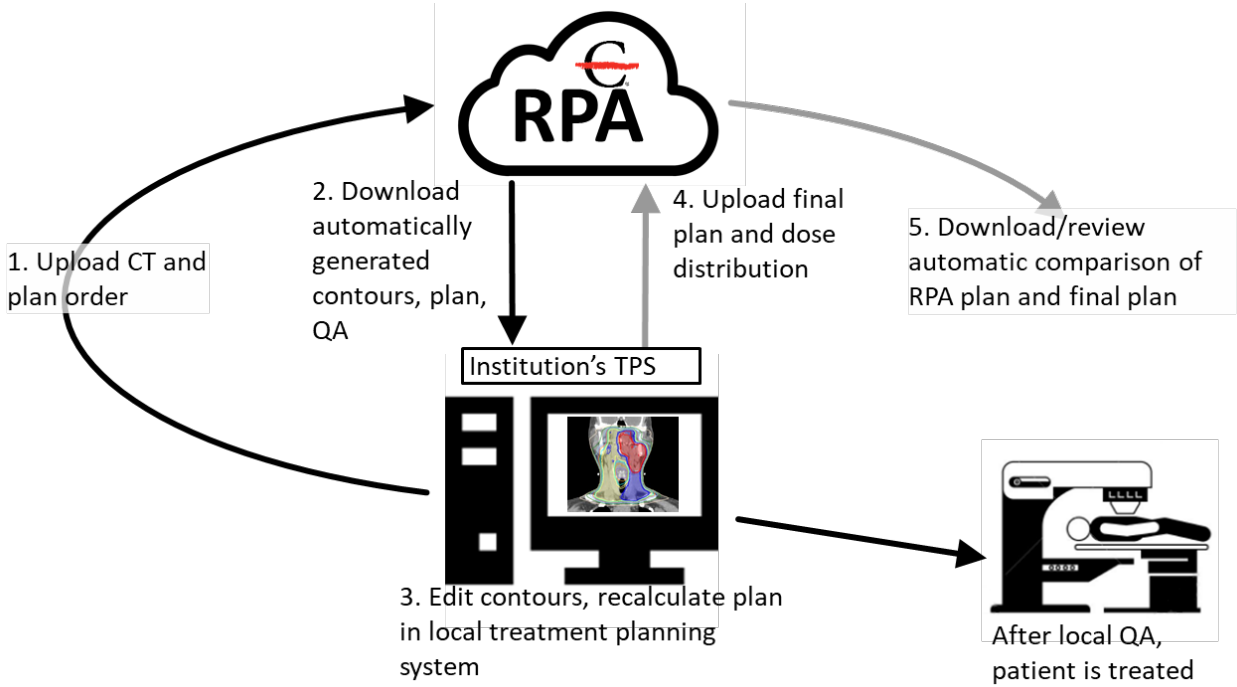
Complexity of Radiotherapy: Potential Impact

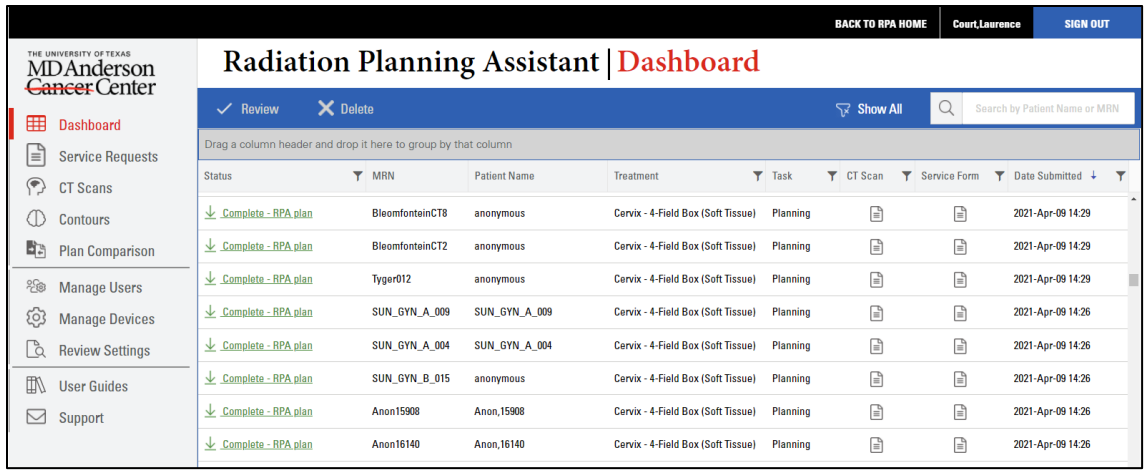


- **Potential Benefits in LMICs**
  - Assist in overcoming workforce challenges
  - Reducing tasks for all involved
  - Reduced inter-observer variability
  - Potential assistance when skills are “new” or limited
  - Increase safety by reduction of human error opportunities

- **Potential Challenges in LMICs**
  - Staff responses
    - Feelings of value, recognition of expertise, fear of unknown
    - Reduced opportunity for training (RTT students, residents)
  - Resource requirements
    - Requires CT planning hardware & software, 3D-capable LINACs
    - Requires department with IT infrastructure/support/service
    - Requires stable internet
  - **Cost**

The Radiation Planning Assistant (RPA)



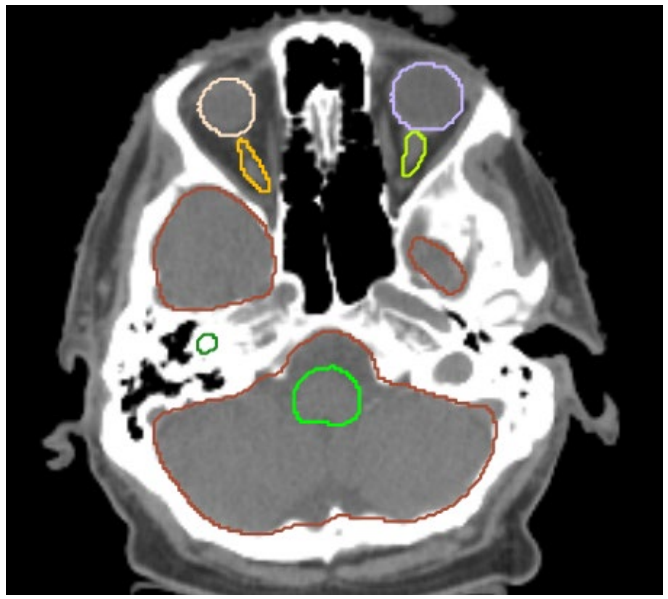


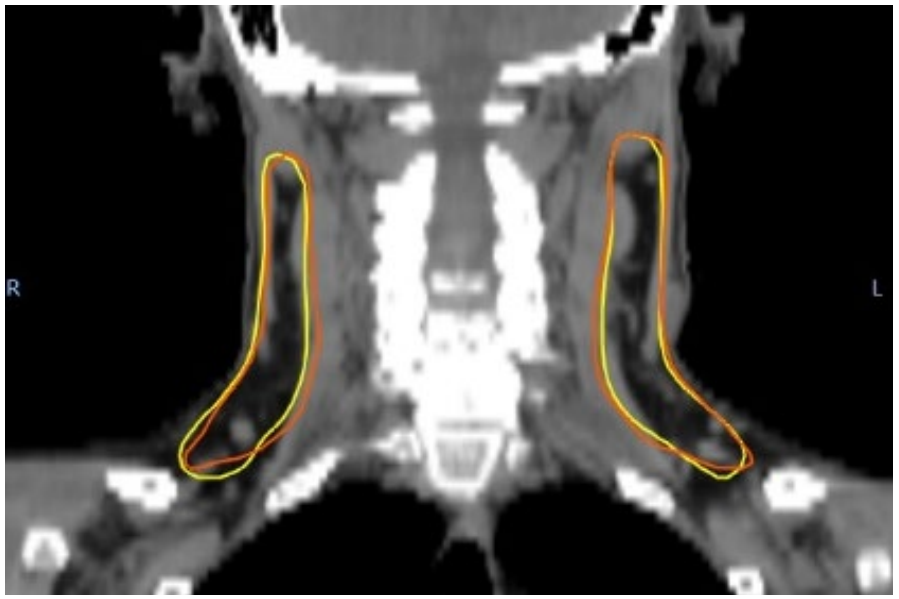
RPA Goals

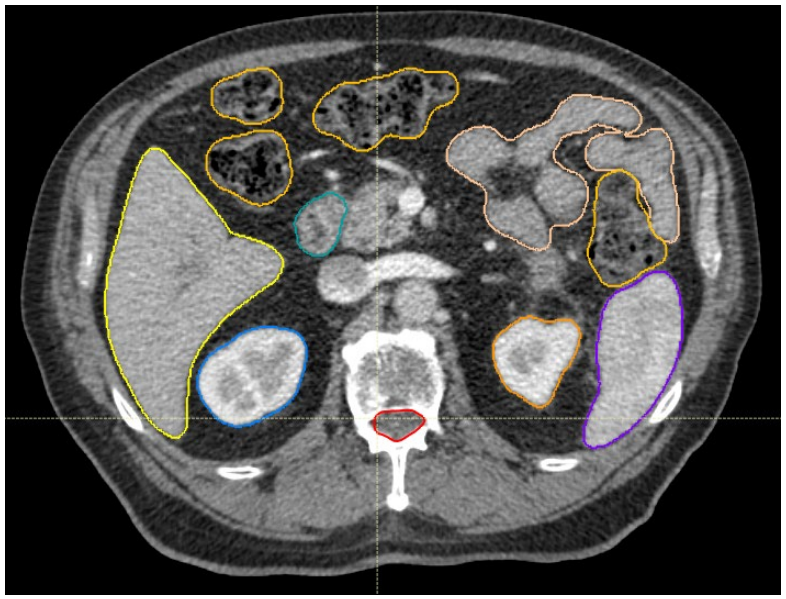
- Designed for scalability
- Web-based solution
- Easy upgrades/maintenance
- Capacity >100,000 patients/year

RPA: Ability to Autocontour Normal Tissues and Targets

Rhee 2020, Cardenas 2021

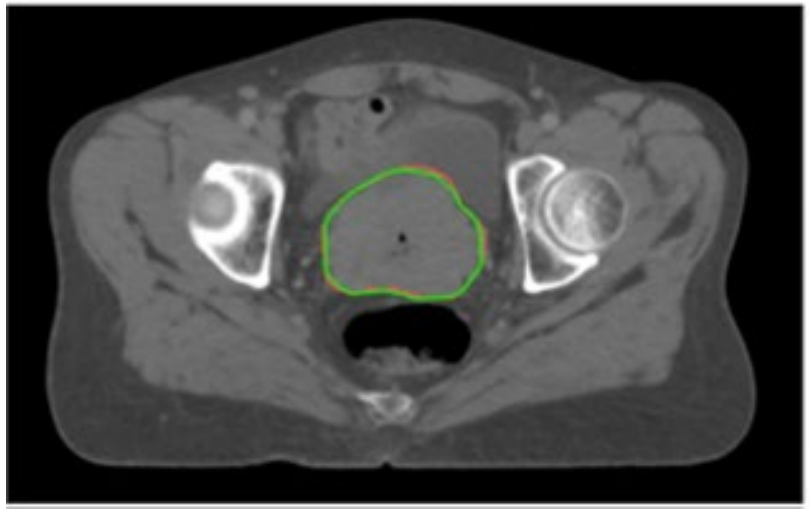


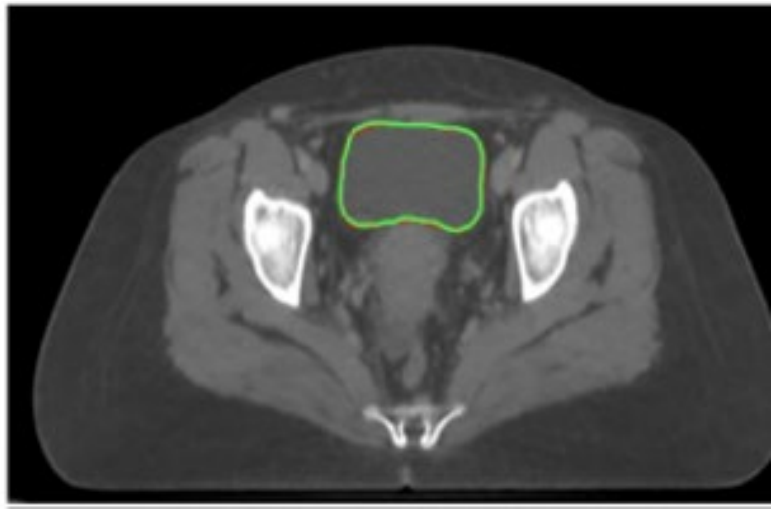


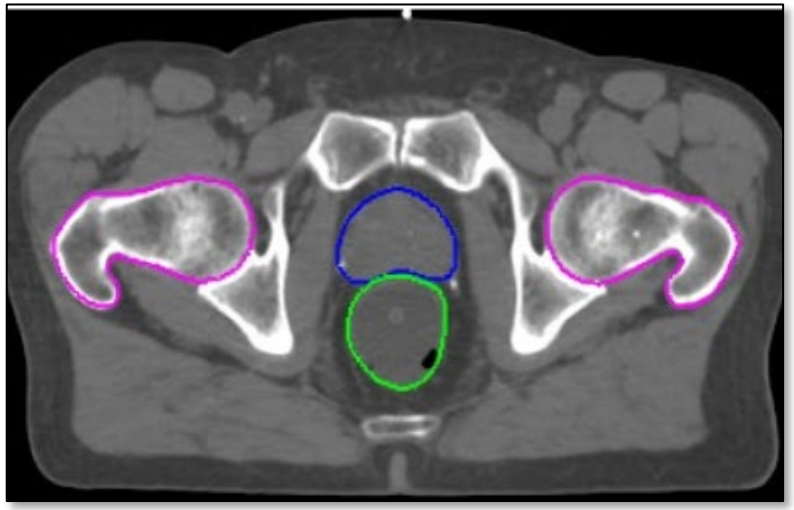


Cenji Yu

Rhee 2020

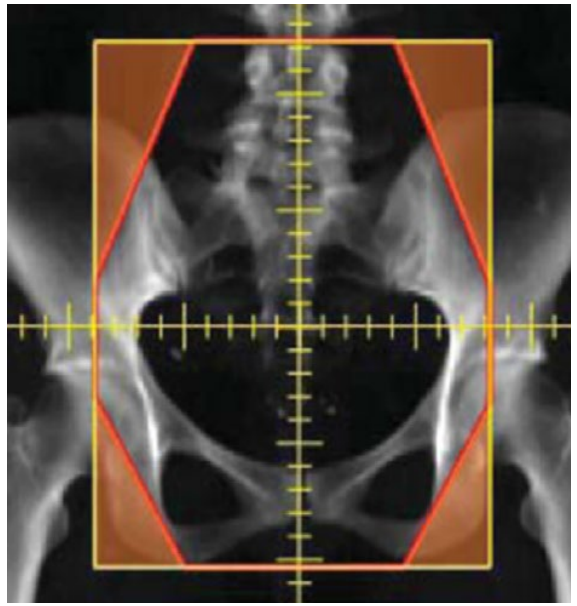




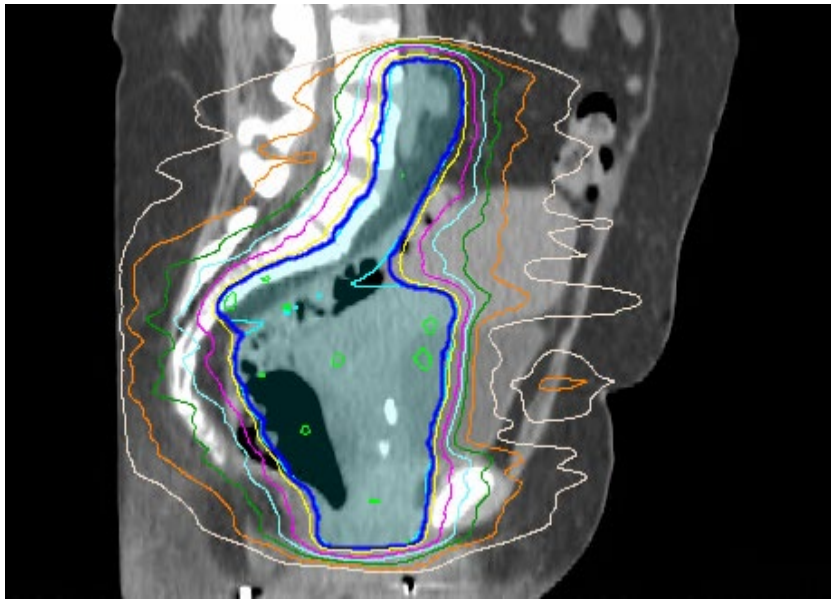


Daniel El Basha

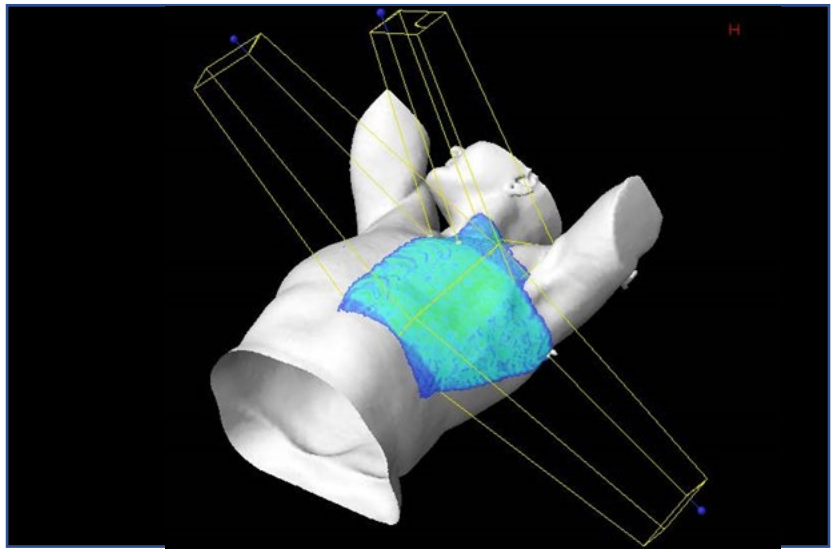
RPA: Ability to Automatically Create High-Quality Radiotherapy Plans



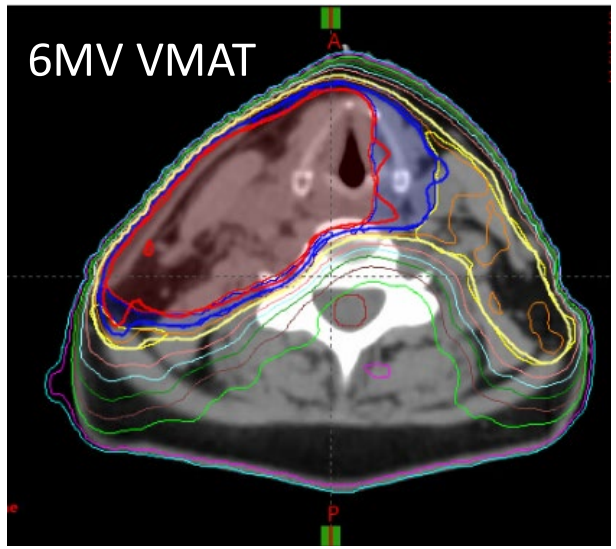
Kisling JGO 2019



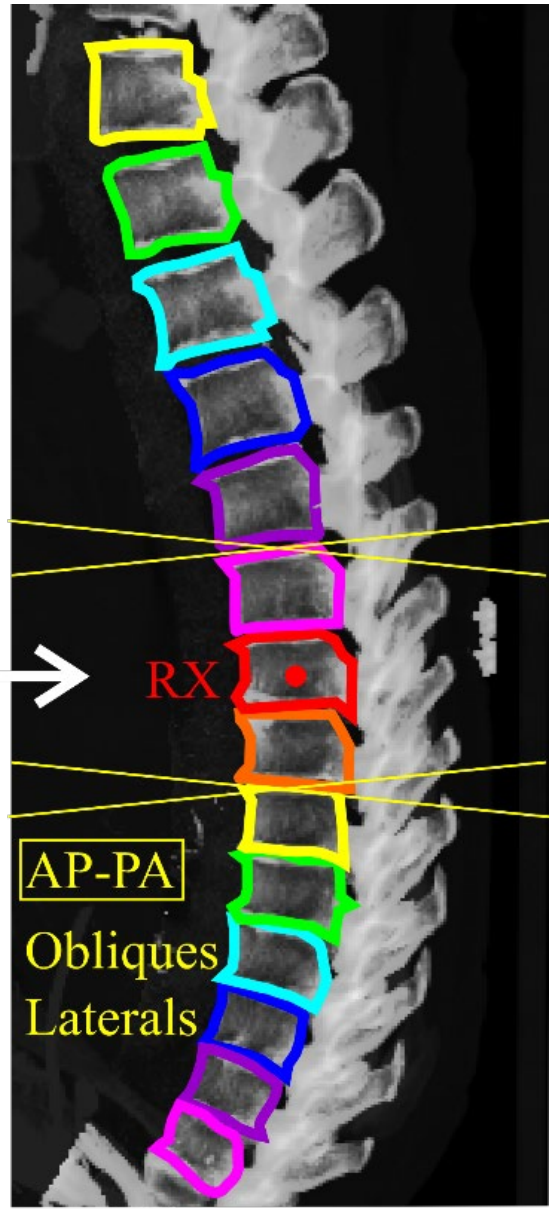
Rhee 2021



Kisling Med Phys 2019



Olanrewaju PRO 2021

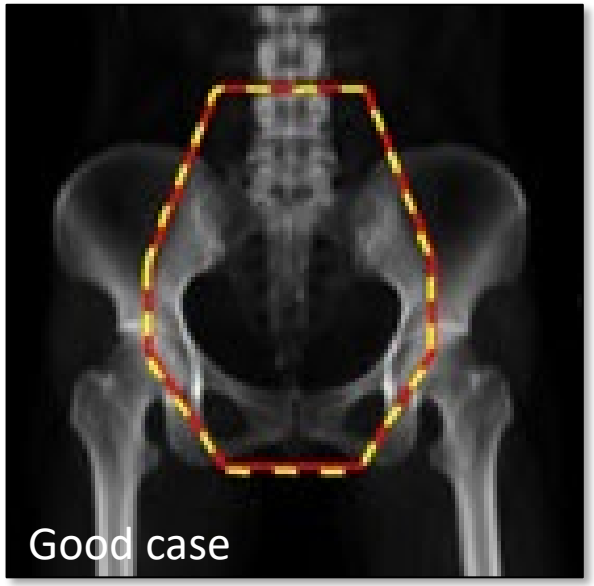


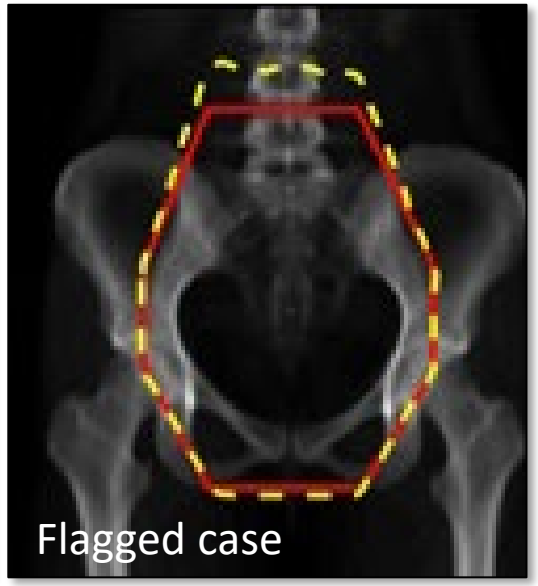
Tucker Netherton

RPA: Ability to Automatically Assure Quality & Identify Potential Failures

- Quality assurance of contours and plans is essential for patient safety
- All automated tasks are repeated with an independent algorithm
- Outliers are flagged to the user for review

Rhee et al 2019





Kisling et al 2020

RPA: Current Status

- Developed RPA for multiple cancer sites, approaches, and treatment paradigms
- Developed solutions based on local practice
  - LMIC centers, patients, clinical teams
- Comprehensive clinical acceptability testing:
  - 31 radiation oncologists
  - 10 institutions
  - 5 countries / 4 continents
  - 75 patients per disease site
  - Almost 8000 ratings
- Overall, 90-100% of RPA-generated contours and plans were acceptable as is or with minor edits (<10 minutes)

	% use as is	% use after minor edits
HNC normal tissue contours	89	97
HNC CTV contours	40	93
HNC VMAT plans	87	96
Cervix normal tissue contours	92	99
Cervix CTV contours	83	92
Cervix bone 4-fld box plans	81	93
Cervix soft tissue 4-fld box plans	79	96
Cervix VMAT plans	99	100
Post-mastectomy breast plans	44	91
Brain planning (MLC shielding)	76	100

- Direct UH2/UH3 output: ~10 papers
- Additional work output: ~15 papers

RPA: Future Plans & Way Forward

- Current Steps Forward:
  - FDA 510(k) submission (sponsor: MDACC) – End of February 2022
  - Begin RPA clinical deployment in South Africa – Late 2022
  - Scale to other LMICs – Applying for additional support

- Future Practical Directions for Maximal Benefit in LMICs:
  - Integrate RPA/AI approach to clinical workflow – LMIC staff need to understand planning process and skills in all necessary steps
  - Educate about ability to critically appraise RPA-generated contours and plans
  - Identify pros/cons to web-based solutions for centers with variable internet
  - Identify long-term solution to RPA infrastructure and sustainability

Acknowledgements

- Affordable Cancer Technologies Program: UH2/UH3-CA202665
- Additional Funding Support:
  - Wellcome Trust – AI for automated planning of palliative radiotherapy
  - Cancer Prevention & Research Institution of Texas (CPRIT) – AI for automated peer review of contours and treatment plans
  - Varian Medical Systems – Additional anatomies and treatment approaches
  - University of Texas MD Anderson Cancer Center
    - Additional cancer sites (including clinical use at MDACC)
    - Running costs (administrative, including legal)
- LMIC partners
- Research team