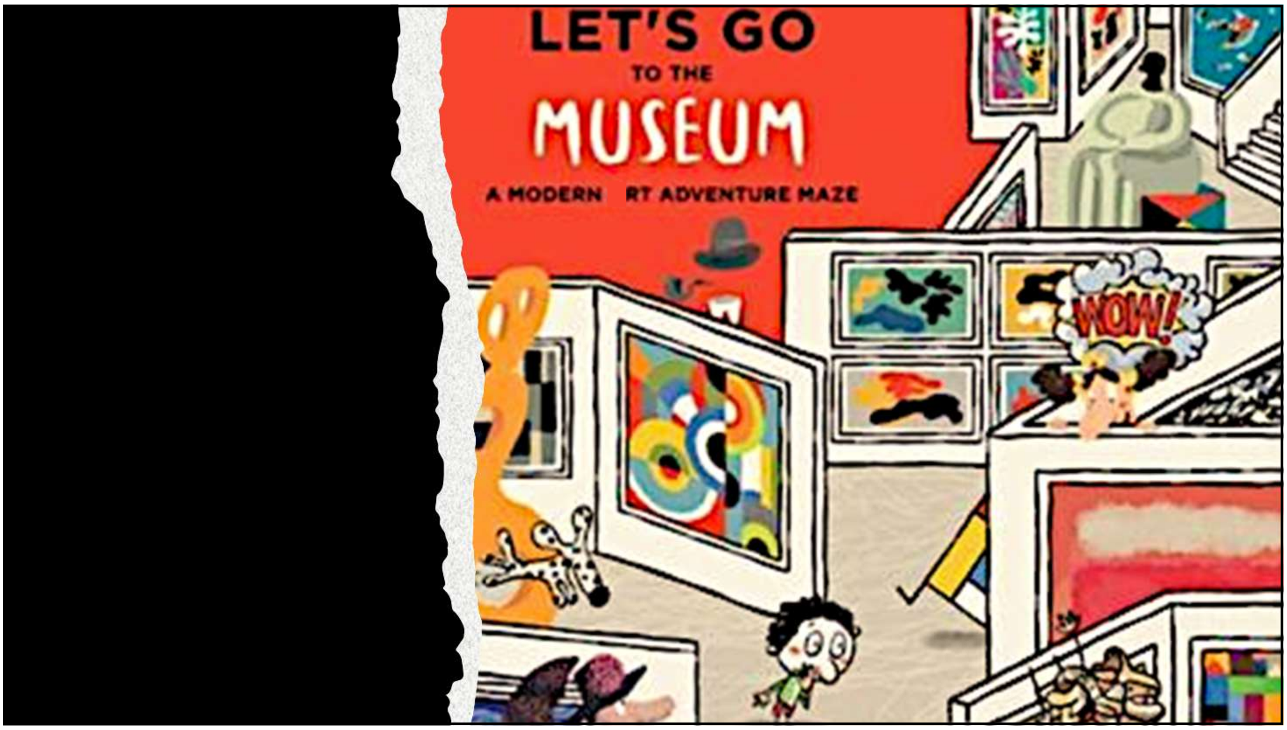
# Hypofractionation as a solution for all

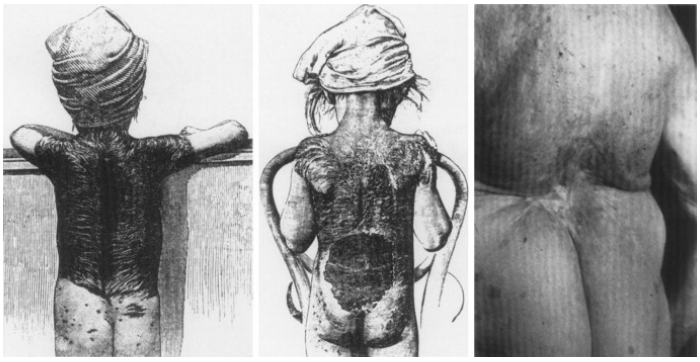
Jean-François Daisne
Radiation Oncologist

netwerk iridium
Topzorg in radiotherapie



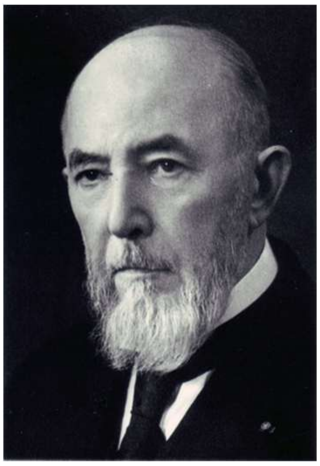


# Leopolod Freund, Vienna, 1896

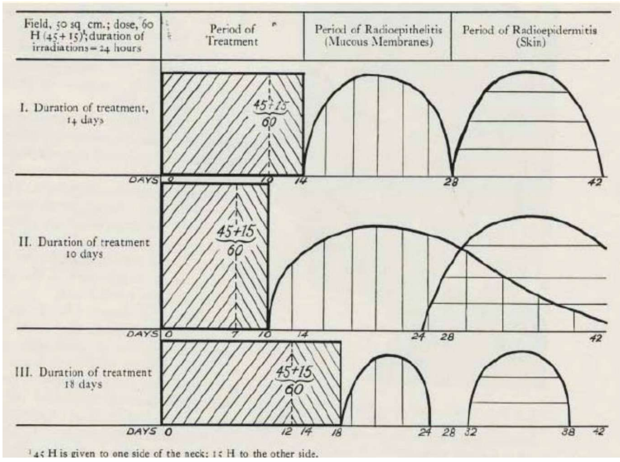





# Claudius Regaud, Lyon, 1911



# Henri Coutard, Paris, 1930






# Clinical application to larynx cancer

The Journal of
Laryngology and Otology

*(Founded in 1887 by* MORELL MACKENZIE *and* NORRIS WOLFENDEN*)*

*July* 1934

THE PROTRACTED-FRACTIONAL X-RAY METHOD (COUTARD) IN THE TREATMENT OF CANCER OF THE LARYNX*

By J. H. DOUGLAS WEBSTER (London)
*(From the Radiological Department, Middlesex Hospital)*

6000 r, 6d/wk, 200 kv, alternate fields

TABLE 3.—*Summary of Roentgen Therapy Results*

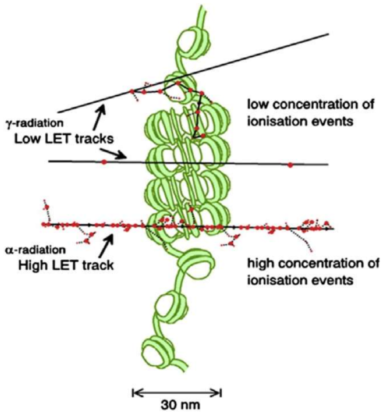
| | | |
|---|---|---|
| Total number of cases treated | | 9 |
| Clinically well (arrested?) | 4 | |
| Improved (but died of subsequent bronchopneumonia) | 3 | |
| Unchanged (no extension) of lesion for some months | 1 | |
| No improvement (died) | 1 | |
| Total number living | | 5 |
| Total number dead | | 4 |

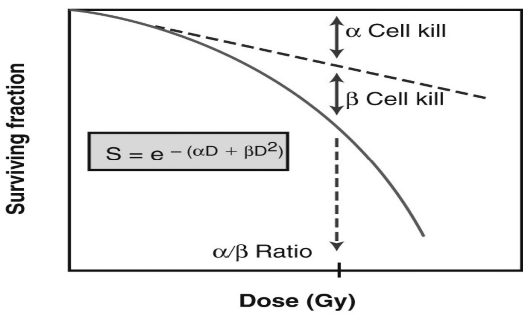
TABLE 6.—*Summary of Surgical Results*

| | | |
|---|---|---|
| Total number of cases operated | | 8 |
| Clinically well (untraced but ? arrested) | 2 | |
| Improved but developed recurrence | 3 | |
| No improvement (died postoperative) | 3 | |
| Total number living unknown, but possibly | | 3 |
| Total number dead | | 5 |

# Modern radiobiology

- Target = DNA
  - Damage ➔ repair or ***direct*** cell lethality

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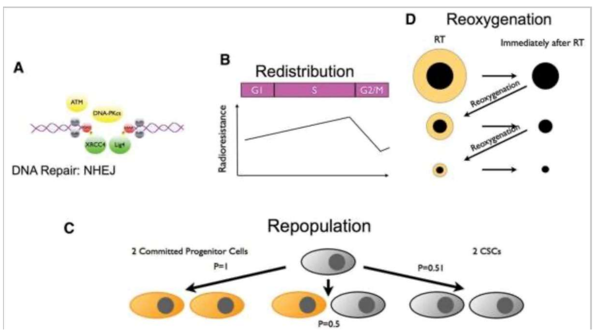
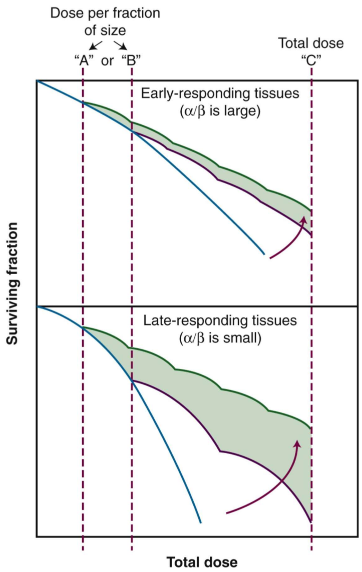
# Modern radiobiology

- Fractionation
  - 4R
  - Different tissues, different responses

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The differential between normal tissue and tumor response is enhanced by dose fractionation, single doses resulting in severe normal tissue injury when the dose is sufficient to control a proportion of treated tumors (Andrews, 1965).

Withers, 1975

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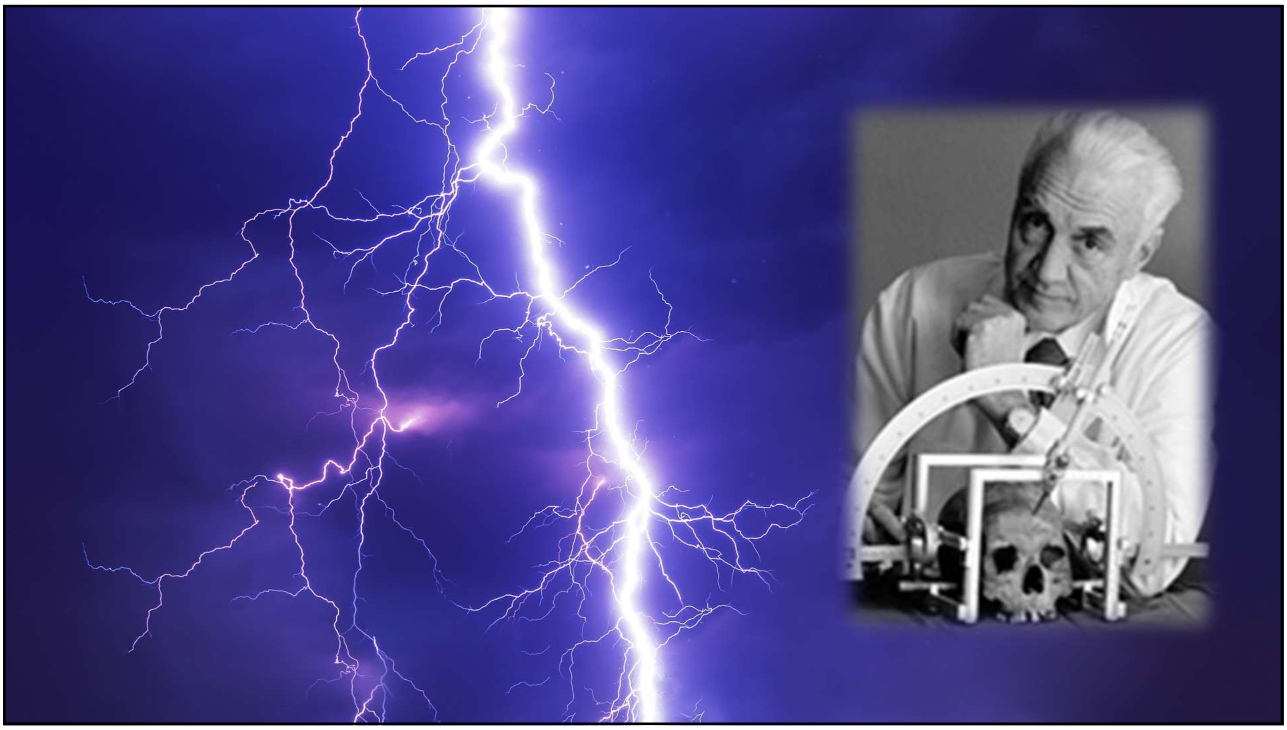

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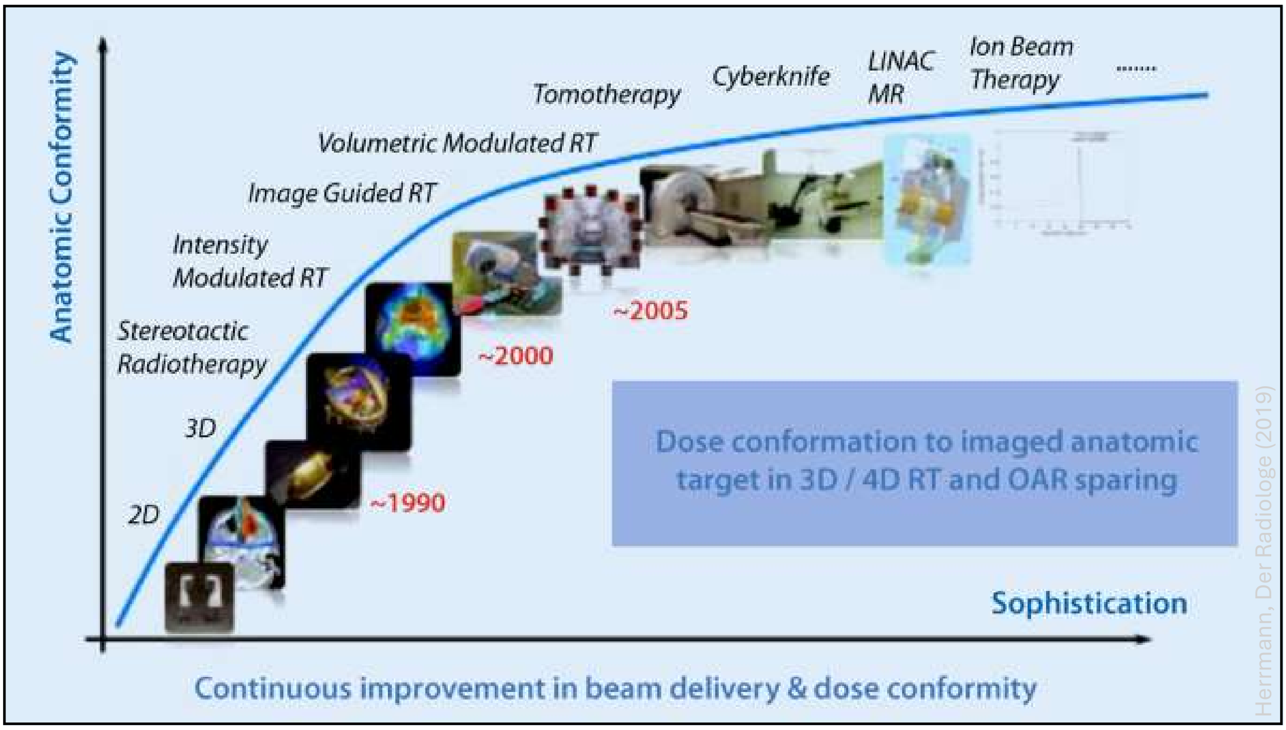
Anatomic Conformity
Ion Beam Therapy
.......
LINAC MR
Cyberknife
Tomotherapy
Volumetric Modulated RT
Image Guided RT
Intensity Modulated RT
Stereotactic Radiotherapy
3D
2D
~2005
~2000
~1990
Dose conformation to imaged anatomic target in 3D / 4D RT and OAR sparing
Sophistication
Continuous improvement in beam delivery & dose conformity
Herrmann, Der Radiologe (2019)

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Benefits

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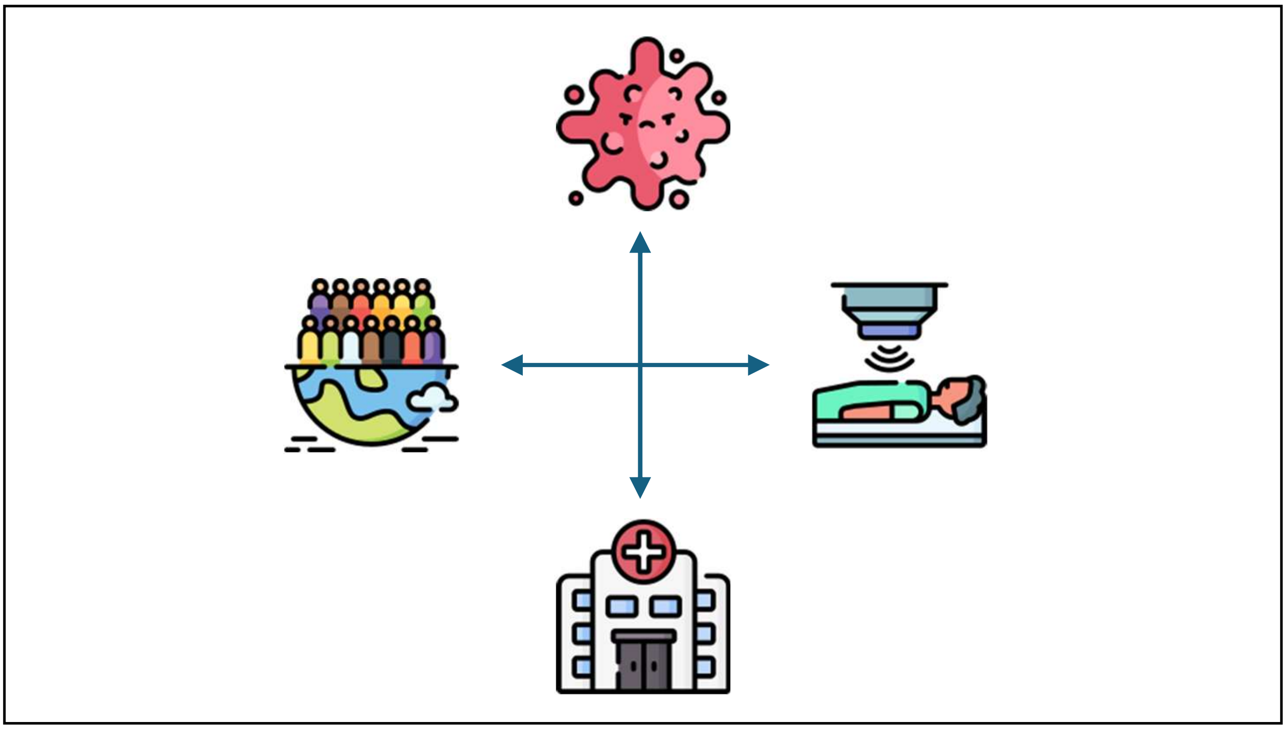

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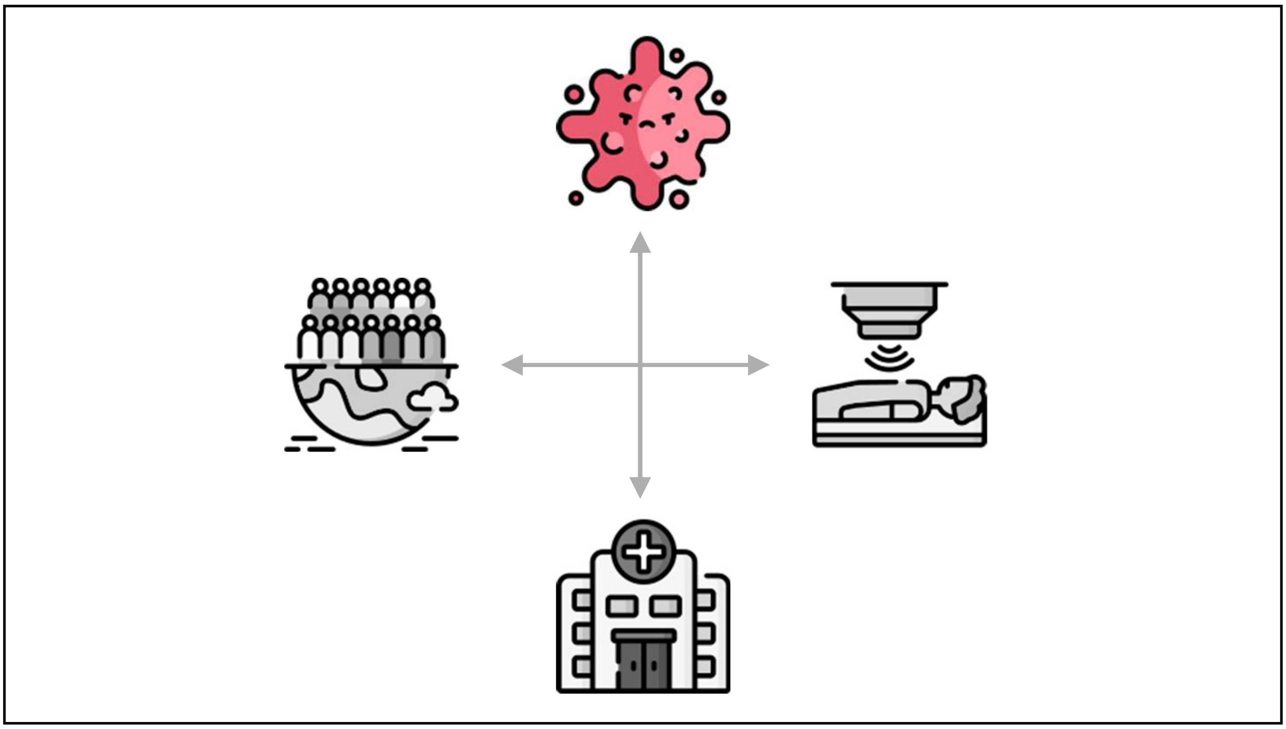

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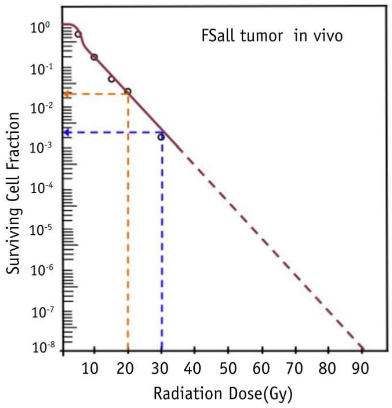
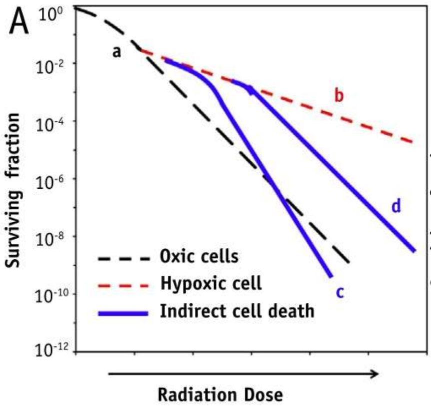
# Tumor biology

- If only direct lethality → unique dose to sterilize 1cc sarcoma lesion ?



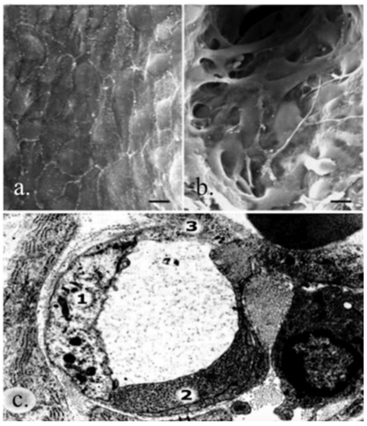



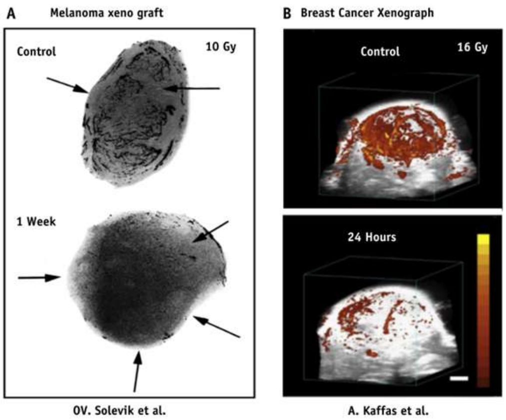

Song, 2021



# Tumor biology

- Indirect lethality: vascular effects

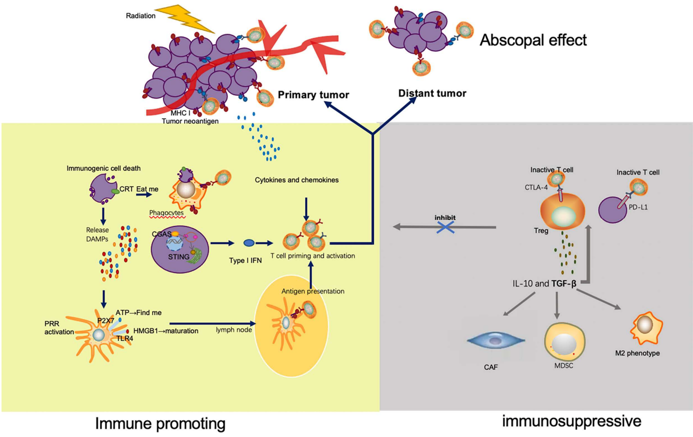



Song, 2021

# Tumor biology

- Indirect lethality: immune effects

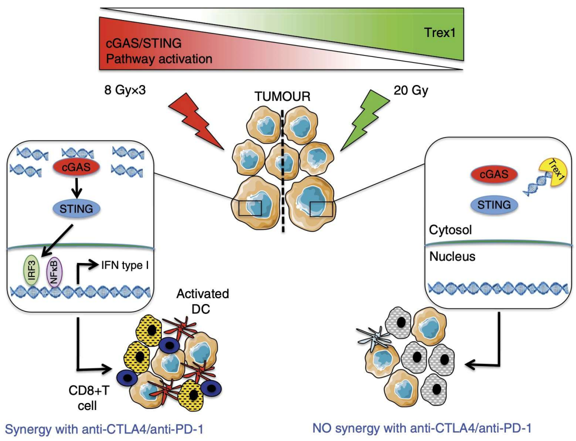



Meng, 2021



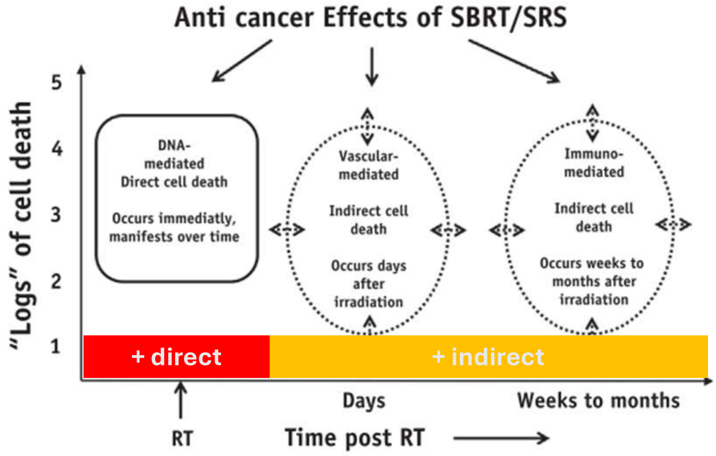
# Tumor biology

- Indirect lethality: immune effects



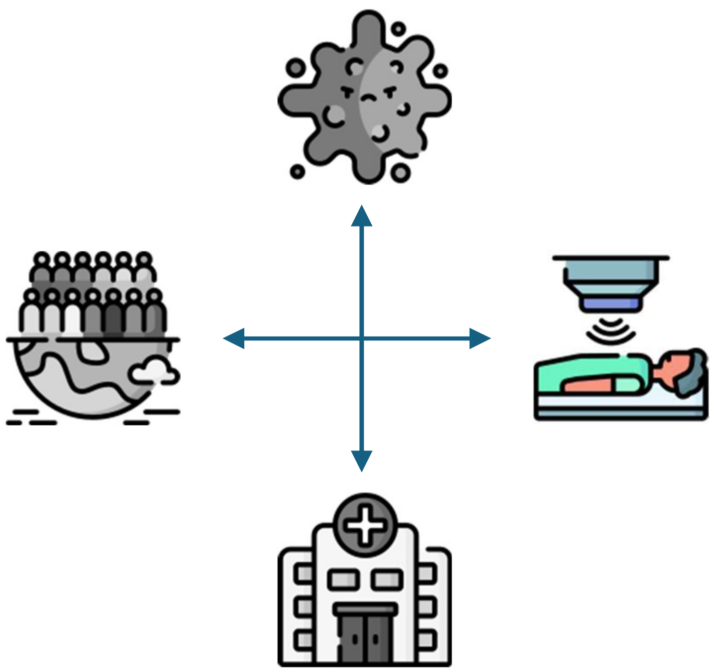

Vanpouille-Box, 2017

# Tumor biology



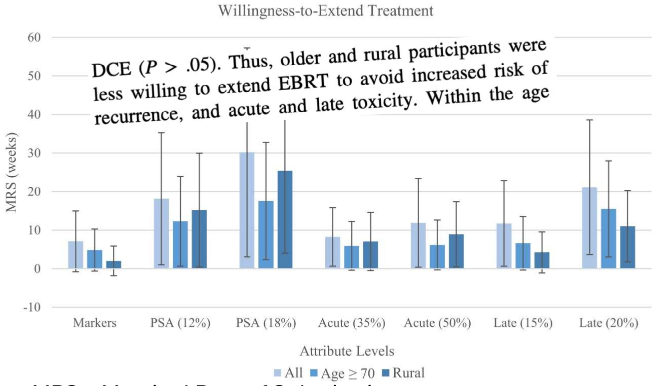

Song, 2021





# Convenience

- Speaks by itself (?)
  - !! Impact of « shared decision making »



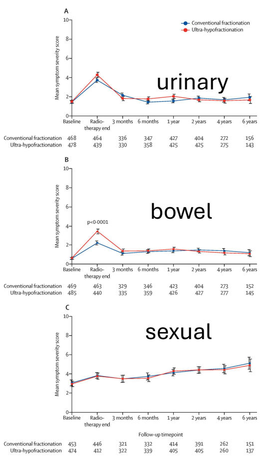

MRS = Marginal Rate of Substitution

Sigurdson, 2022

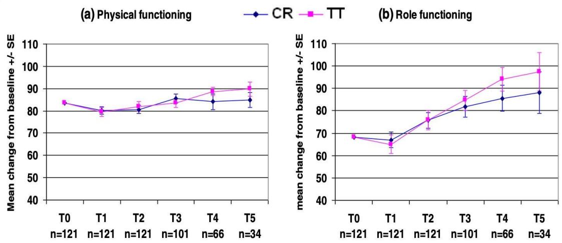


# Quality of life

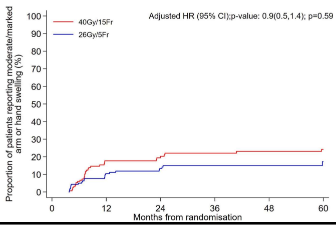
- Symptoms burden evolution




Fransson, 2021




Versmessen, 2012




Brunt, 2025

# Quality of life


Van Hulle, 2020

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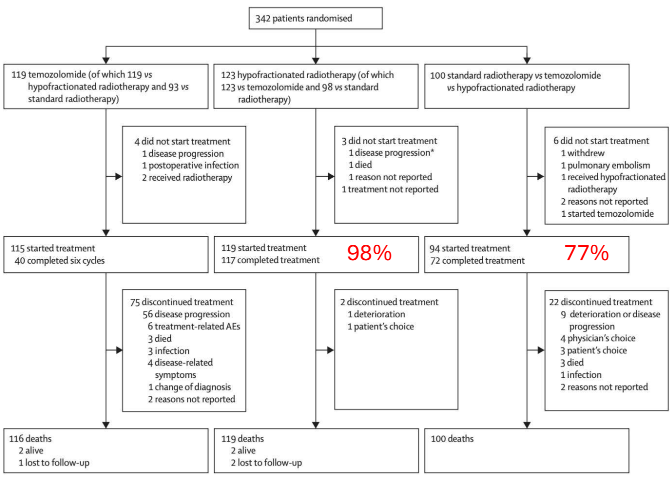
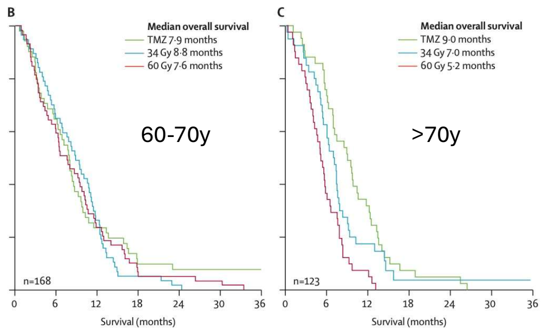
# Compliance




Malmström, 2012

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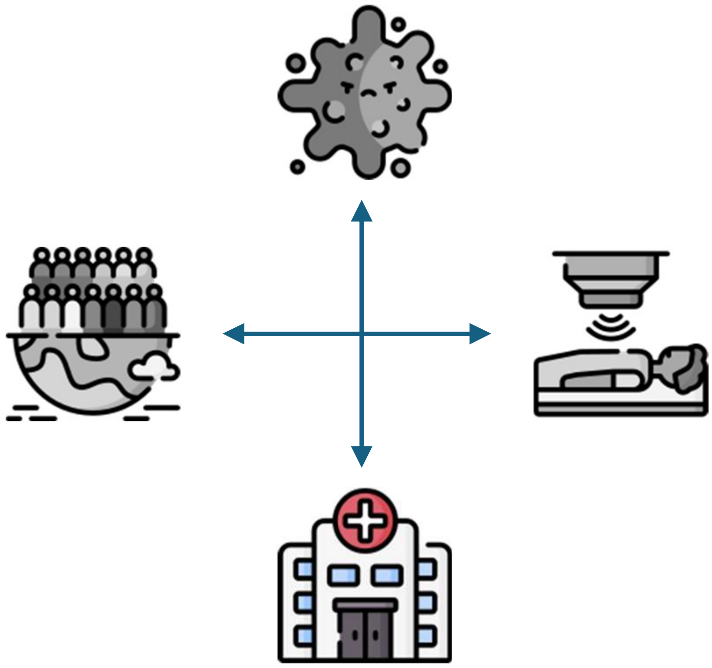

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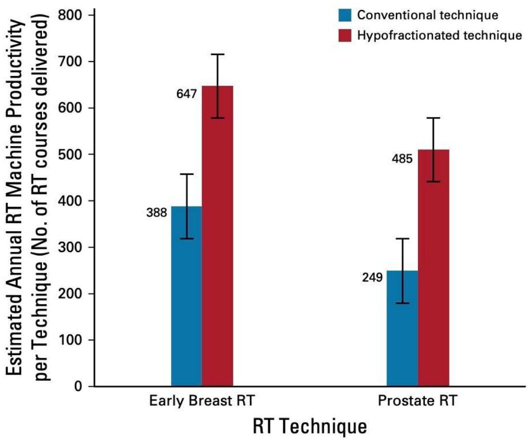
# Device usage optimization

- Improving access
  - LMIC’s
  - Facing increasing numbers
- Decreasing investment costs
  - Cave: high tech machines
    - More expensive




Irabor, 2020

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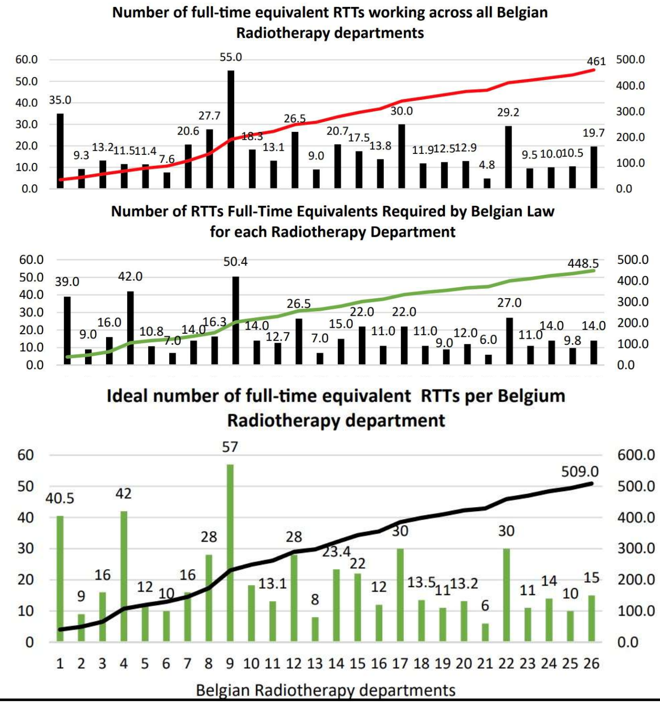


Sousa, 2021



# Staff shortage / retention

## University of Texas

**Table 2** Effects of Hypofractionated Treatments on Treatment Capacity

| | Hypofractionated Treatments | Fractionated Treatments | Capacity Scenario |
|---|---|---|---|
| Treament Delivered/Patient | 12 | 25 | 25 |
| Time In Vault in Mins | 30 | 30 | 30 |
| Patient Volume | 4109 | 4109 | 4109 |
| Primary Linacs | **17** | **17** | **31** |
| Time per patient | 360 | 750 | 750 |
| Total time per year (mins) | 1,479,240 | 3,081,750 | 3,081,750 |
| Total time per year (hours) | 24,654 | 51,363 | 51,363 |
| Days per week | 5 | 5 | 5 |
| Weeks per year | 50 | 50 | 50 |
| Patient Hours/day | 99 | 205 | 205 |
| Patient Hours/Linac | 5.8 | 12.1 | 6.6 |
| Turn over hours/day | 1.25 | 1.25 | 1.25 |
| Total Hours Utilized/linac | 7.1 | 13.3 | 7.9 |
| Ideal Hours Utilized/linac | 8 | 8 | 8 |
| % Ideal State | **88%** | **167%** | **98%** |

Lin, 2024

# Staff shortage / retention

- Short time solution
- Reduces over-hours
- Highly technical: more appealing for "radiographers"
- Increases engagement

- Not on the long time
- Investment in education & quality management
- Highly technical, less patient contact: less appealing for « nurses » ?

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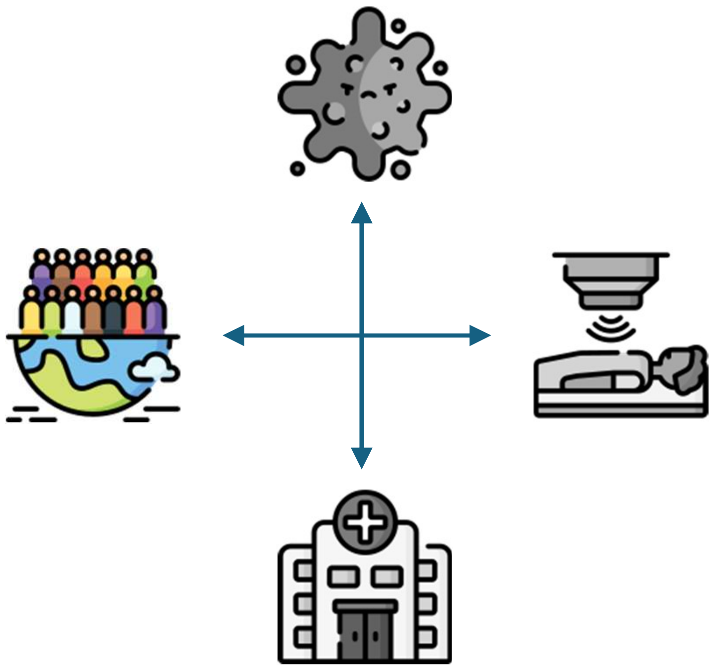

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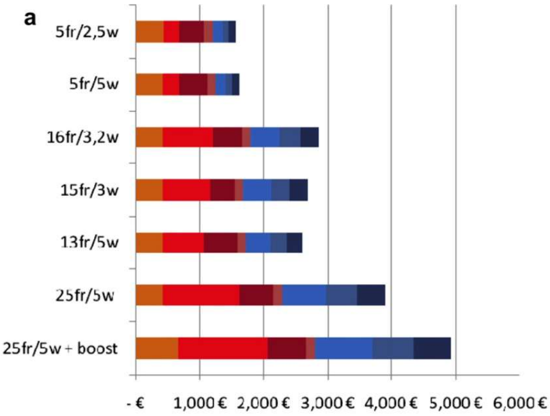
# Economical sustainability

- More investment, but less fractions




Lievens, 2010

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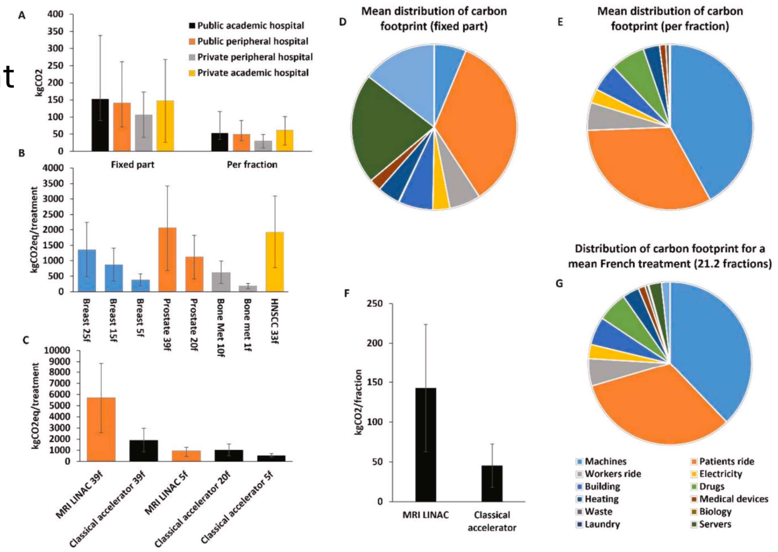
# Ecological sustainability

- Life Cycle Assessment




Dupraz, 2024

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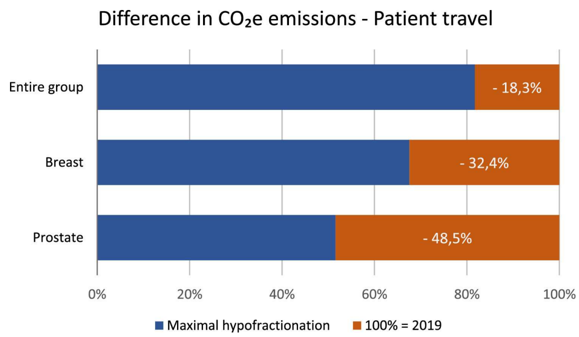
# Ecological sustainability

- Optimizating hypofractionation

| Group | Number of patients | 2019 situation: Median number of fractions | 2019 situation: Total number of visits | 2019 situation: Estimated $CO_2e$ (t) | Maximalized hypofractionation: Median number of fractions | Maximalized hypofractionation: Total number of visits | Maximalized hypofractionation: Estimated $CO_2e$ (t) | Decrease in $CO_2e$ (%) |
|---|---|---|---|---|---|---|---|---|
| All patients | 2625 | 16 | 43,433 | 394 | 6 | 33,711 | 322 | 18.3 |

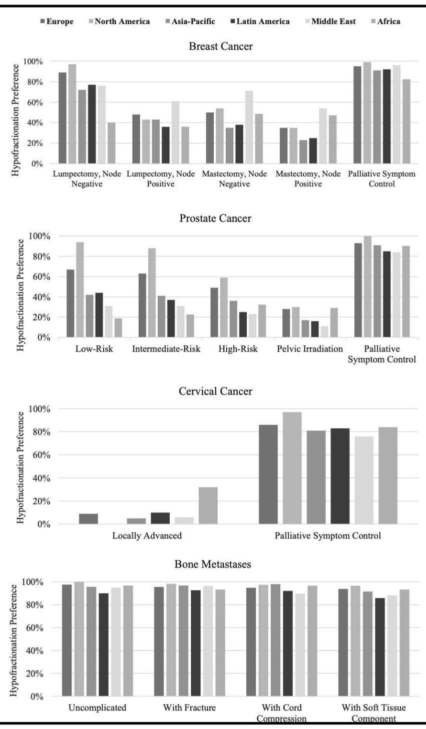


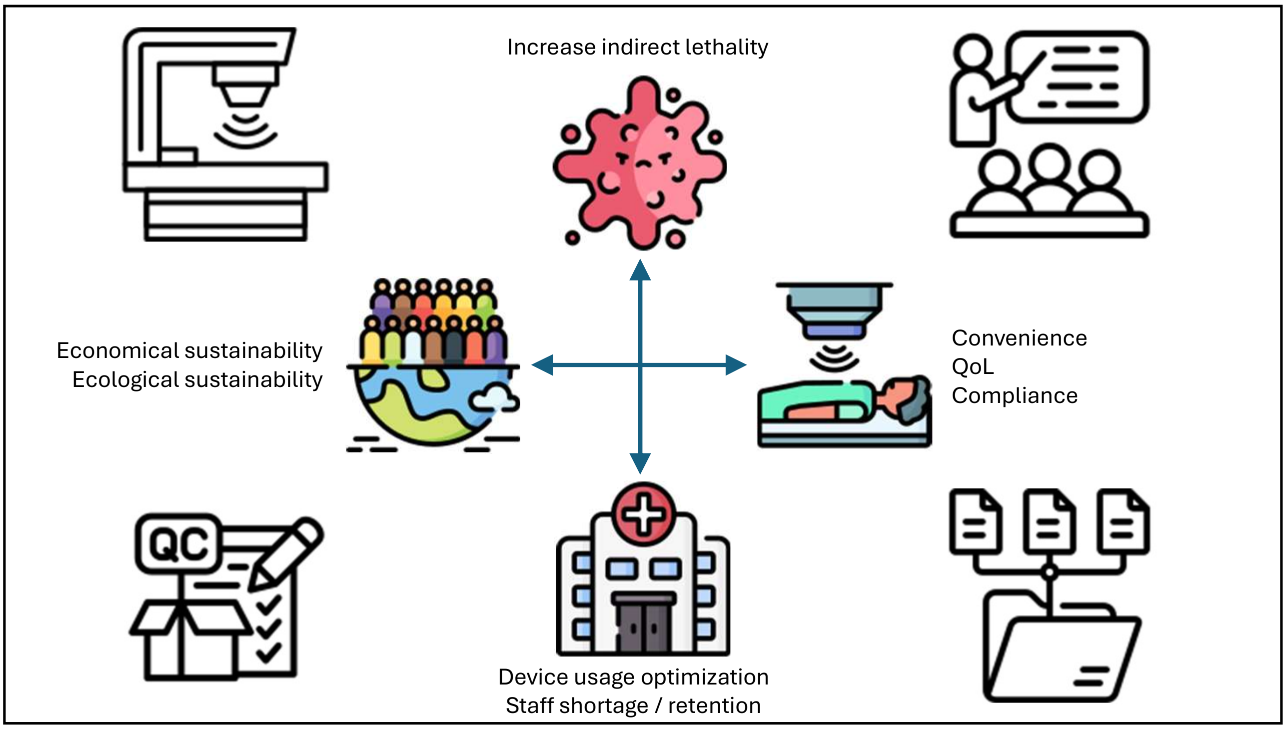

Vanmarcke, 2025



# (Non) Adoption in the world

- ESTRO-GIRO survey
  - 01/2018 – 01/2019
  - N = 2316 RO
  - Barriers:
    - Lack of long term data
    - Concerns about LC / Tox
  - Negative predictors:
    - LMIC
    - Asia-Pacifi
    - Female respondent
    - Small cachment area (pop < 1M)
    - No access to IMRT




Increase indirect lethality
Economical sustainability
Ecological sustainability
Convenience
QoL
Compliance
QC
Device usage optimization
Staff shortage / retention