Global Access to Radiotherapy for Lung Cancer
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IASLC  
INTERNATIONAL ASSOCIATION  
FOR THE STUDY OF LUNG CANCER  
Conquering Thoracic Cancers Worldwide

CME ACCREDITED
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All relevant financial relationships have been mitigated.
Global RT capacity and challenges for treating lung cancer with RT in LMICs

Fabio Ynoe de Moraes, MD, PhD
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Queen’s University – Kingston Health Sciences Centre
Cancer statistics

- Increasing to 30.2M new cases and over 17M deaths by 2040.
- Globally 1 in 5 people are being diagnosed with cancer
  - 1 in 8 men, 1 in 11 women die from cancer
  - 50M living within 5 years for cancer diagnosis
- **Lung cancer** is second in number of new cases (2.2M) and the leader in cases of death (1.8M)

**Radiotherapy has a major role to play in the management of this patients**

Radiotherapy

1 in 2 cancer patients worldwide would benefit from radiation

40% are curable with radiation

The need for RT is clear

RT improves control and quality of life

Potential to save 1M live per year

Potential to promote positive economical impact

By 2040, 67% of annual cancer cases will be in LMIC and there is no adequate resource mobilization to tackle this future challenge.

> 2 million people are unable to access RT
Low- and middle-income countries are particularly disadvantaged by this deficit.


Barriers to RT

- Lack of access to RT
- Issues with quality control and safety
- Lack of sustainable investment
- Lack of trained personnel

There are many barriers to RT in LMIC
Cost and benefits of scaling up RT in LMIC

Figure 11: Cost and benefits of investments to scale up radiotherapy services in low-income and middle-income countries, 2015-35
The costing models are described in the text and include both operational and capital costs.

RT use for Lung cancer in LMIC

› The standard of care for lung Ca treatment involves RT
  › curative-intent treatment of early-stage to locally advanced disease, as well as in palliation.

› The infrastructure, equipment, and human resources required for RT may be limited in LMICs.

› Priorities:
  › increase access to RT equipment and trained health care professionals
  › encouraging innovation to increase the economic efficiency of RT delivery.

Before the mid-1990s, RT planning relied on two dimensional imaging.

The development of three-dimensional conformal RT (3D-CRT) and intensity-modulated RT (IMRT) (mid-1990s)

- allowed better delineation of normal structures (termed organs at risk) and target volumes

Recent improvement related to the assessment of patient positioning and the tumor.
Conventional versus SABR for early stage

<table>
<thead>
<tr>
<th>Nyman et al.(^\text{a})</th>
<th>Ball et al.(^\text{b})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPACE</strong></td>
<td><strong>CHISEL</strong></td>
</tr>
<tr>
<td><strong>n</strong></td>
<td><strong>102</strong></td>
</tr>
<tr>
<td>Diagnosis and staging</td>
<td>63% Pathological confirmation</td>
</tr>
<tr>
<td>Randomization</td>
<td>65% PET scan</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>75</td>
</tr>
<tr>
<td>Comorbidity</td>
<td>64% CVD</td>
</tr>
<tr>
<td>T stage</td>
<td>T1 75%</td>
</tr>
<tr>
<td>LC (%)</td>
<td>85.7</td>
</tr>
<tr>
<td>PFS (%)</td>
<td>3 y 42%</td>
</tr>
<tr>
<td>OS</td>
<td>2 y 72%</td>
</tr>
<tr>
<td>Grade 1+ oesophagitis (%)</td>
<td>30(^\text{a})</td>
</tr>
<tr>
<td>Grade 1+ pneumonitis (%)</td>
<td>34</td>
</tr>
</tbody>
</table>

\(^\text{a}\)Statistically significant.

COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; fr, fractions; Gy, Gray; LC, local control; NSCLC, non-small cell lung cancer; OS, overall survival; PET, positron emission tomography; PFS, progression-free survival; SABR, stereotactic ablative body radiotherapy; SCS, simplified comorbidity score; y, years.


## Global RT capacity

**Table 1. Summary of radiotherapy capacity in Europe, Africa, Asia, Latin America and the Caribbean, and North America**

<table>
<thead>
<tr>
<th>Region</th>
<th>Infrastructure</th>
<th>Equipment</th>
<th>Human resources</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Europe</strong></td>
<td>1286 RT centers; more than two-thirds in Germany, Italy, France, the United Kingdom, and Spain</td>
<td>3157 MV machines represent 19% of unmet need; 92% of machines are linear accelerators</td>
<td>6000 radiation oncologists, 3000 medical physicists, and 10,000 RT technologists</td>
<td>Range of RT capacity follows GNI distribution; many centers perform advanced RT techniques (IMRT, SABR)</td>
</tr>
<tr>
<td><strong>Africa</strong></td>
<td>160 RT centers; 29 countries (20% of population) do not have any machines</td>
<td>277 MV machines, 68% linear accelerators; machines weighted heavily toward South Africa (33%) and Egypt (27%)</td>
<td>No up-to-date data on number of RT professionals; presence of training facilities noted in only 7 countries</td>
<td>Little known about types of plans delivered</td>
</tr>
<tr>
<td><strong>Asia</strong></td>
<td>1462 RT centers; 86% of centers located in Japan, China, and India</td>
<td>3051 MV machines identified, high country-to-country disparity in number of machines per million population</td>
<td>Radiation oncologists and therapists serve in multiple roles; only 17 countries meet human personnel guidelines</td>
<td>Little known about types of plans delivered</td>
</tr>
<tr>
<td><strong>Latin America &amp; Caribbean</strong></td>
<td>470 RT centers, most densely available in Argentina, Chile, Panama, Uruguay, and Venezuela</td>
<td>710 MV machines, 44% linear accelerators; estimated 100 more machines needed</td>
<td>69% more radiation oncologists, 146% more medical physicists, and 109% more RT technologists needed</td>
<td>Only 3% of centers able to generate IMRT plans</td>
</tr>
<tr>
<td><strong>North America</strong></td>
<td>3388 RT centers between United States (3331) and Canada (57)</td>
<td>4240 MV machines between United States (3956) and Canada (284), 96% are linear accelerators</td>
<td>4236 radiation oncologists, robust medical physics training programs</td>
<td>Quality assurance measures not well described; many centers perform advanced RT techniques (IMRT, SABR)</td>
</tr>
</tbody>
</table>

RT, radiotherapy; MV, megavoltage; GNI, gross national income; IMRT, intensity-modulated radiotherapy; SABR, stereotactic ablative radiotherapy.

Strategies for RT delivery in minimal resource settings

### Table 2. Resource-tiered technological guidelines

<table>
<thead>
<tr>
<th>Indications</th>
<th>Simulation</th>
<th>Treatment technique</th>
<th>Oncology center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palliative treatment of locally advanced primary and metastatic lung tumors</td>
<td>2D and CT simulation</td>
<td>2D treatment (rectangular portals) and 3D CRT</td>
<td>Tier 1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Routine radical radiotherapy and chemoradiation of lung cancers</td>
<td>CT simulation</td>
<td>3D CRT</td>
<td>Tier 2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Complex cases of radical radiotherapy and chemoradiation</td>
<td>CT simulation</td>
<td>IMRT and IGRT</td>
<td>Tier 3&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Specialized techniques such as SABR</td>
<td>CT simulation, including 4D techniques</td>
<td>IMRT, IGRT, and 4D treatment</td>
<td>Tier 3&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Tier 1: basic oncology center with cobalt machine.
<sup>b</sup>Tier 2: intermediate oncology center with basic linear accelerator and CT-based simulation.
<sup>c</sup>Tier 3: advanced- level oncology center with linear accelerators, CT simulation, and image guidance. 2D, two-dimensional; CT, computed tomography; 3D CRT, three-dimensional conformal therapy; 4D, four-dimensional; IMRT, intensity-modulated radiotherapy; IGRT, image-guided radiotherapy; SABR, stereotactic ablative radiotherapy.

Summary

- EXPANSION OF RT CAPACITY IS NEEDED NOW
- SUSTAINABLE FUNDING FOR RT SHOULD BE PROVIDED
- RT PROVIDE BOTH HUMAN AND ECONOMICAL BENEFIT
- RT FOR LUNG CANCER:
  - Invest in both human capacity and treatment resources,
  - Ensure quality of care,
  - Provide guidance on priority setting with limited resources, and
  - Foster innovation to increase the economic efficiency of RT delivery.
Health Human Resources and Access to Thoracic Cancer Care

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No care without a workforce
Crisp, WHO, 2010

**Quick wins**
- e.g. better infrastructure use of ICTs

**Scale-up outcomes**
- e.g. lower attrition more CHWs, better system management

**Key enablers**
- e.g. curriculum reform, HRH observatories

**Health outcomes**
- e.g. more mid-level cadres, better public-private provider mix

**Longer term**
- e.g. new educational institutions, more regional partnerships

**Health outcomes**
- e.g. more high-level cadres, better knowledge management

MDG 4
- Chronic disease management

MDG 5
- MDG 6

Crisp, WHO, 2010
Global Curricula
Explore Multiple Alternatives

ROUTE I
Secondary school → Medical school (undergraduate) → Residency (postgraduate)

ROUTE IV
Secondary school → Medical school (undergraduate) → Internship (postgraduate) → Mandatory service → Residency (postgraduate)

ROUTE V
Secondary school → Bachelor / college → Medical school (undergraduate) → Residency (postgraduate)

Wijnen-Meijer, Medical Teacher, 2013
“Healthcare crisis fuelled by mismatch between curricula and the needs of patients, families and the health-care system”

Frenk, Lancet, 2010
Universalism

“International standards, which have general applicability for medical education, can be defined.”

(World Federation for Medical Education 2003)
“Curricula often become closely linked to historical legacy that codifies the traditions, priorities and values of the faculty in that profession. Over time the curriculum is rarely re-examined but is slowly modified to accommodate new information”

Frenk, Lancet, 2010
Task Shifting

Skills Mix (vs Staff Mix)
Task Shifting

Skills Mix (vs Staff Mix)
Vertical & Horizontal Substitution

Nancarrow SA, Borthwick AM. Sociology of Health & Illness, 2005
Integrated Caregiver Supports

Current Caregiver Training
- No caregiver resources

Future Caregiver Training
- Caregiver Education, Support & Skills Program
- Medium intensity intervention, eg: CALM, Sexual Health Clinic
- High intensity intervention, eg: one-on-one therapy

Intensity of caregiver needs
- High
- Low

Cost effectiveness and accessibility
- Cost effective, wide accessibility
- Expensive, limited accessibility

Giuliani & Papadakos
Whose Priorities?

Global–Local Dynamics
Neocolonialism in medicine
Globalization + Technology
<table>
<thead>
<tr>
<th>Traditional</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>UME</td>
</tr>
</tbody>
</table>

The diagram compares Traditional and Future in terms of School, UME, PGME, and CPD.
Medical education must become both the vehicle and the object of reform.

Tina Martimianakis
(2016)
Innovation and research to increase access to RT

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Global variations in Lung Cancer Incidence

Zhang Y, et al. JTO 2021; 16: 933
Increasing LC incidence driven by Low-Medium HDIs

- Funding
- Lacking cancer registries
- Health care systems
- Infrastructure
- Access to RT

IARC - GLOBOCAN 2021
Addressing RT utilization in Lung Cancer

Actual RT Utilization Rate: 21% to 52%
Optimal RT Utilization Rate: 62% to 82%

What happens with LMICs?

Many organizations improving access to RT

- International Atomic Energy Agency (IAEA)
  - Program of Action for Cancer Therapy (PACT)

- Union for International Cancer Control (UICC)
  - Global Task Force on Radiotherapy for Cancer Control

- Several partnerships HIC academic - LMIC institutions

- Others
  - Above&Beyond Cancer, AMPATH, AORTIC, ALIAM, AAPM, ASTRO,…
International Atomic Energy Agency (IAEA)

- Improving access to safe and efficient RT, diagnostic imaging, and nuclear medicine
- Coordinated Research Programs
- IRIS platform
- Directory of Radiotherapy centers
- Human Health Campus
Research focusing on global access to RT

- Introducing RadOncs in LMICs to clinical research activities
- Minimize selection bias in clinical trials
- Knowledge gap between EBIs and delivery
- Innovation in education. Blended learning
- Hardware

Abdel-Wahab M., et al. JCO Glob Oncol 2021; 7: 827
Opportunities for innovation and collaboration

› Telecommunication

› Automation

› Remote support

› Virtual collaborative spaces

› Blended learning
## Implementation Research

<table>
<thead>
<tr>
<th>Process</th>
<th>Technology</th>
<th>Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment and prescription</td>
<td>CT simulator</td>
<td>Radiation oncologist</td>
</tr>
<tr>
<td>Imaging for treatment planning</td>
<td>Planning system</td>
<td>Radiation technologist</td>
</tr>
<tr>
<td>Treatment volume determination</td>
<td>Planning system</td>
<td>Radiation oncologist</td>
</tr>
<tr>
<td>Treatment planning</td>
<td>Recording and verification</td>
<td>Dosimetrist</td>
</tr>
<tr>
<td>Pretreatment review and quality-control checks</td>
<td></td>
<td>Radiation oncologist</td>
</tr>
<tr>
<td>Data transfer</td>
<td></td>
<td>Medical physicist</td>
</tr>
<tr>
<td>Treatment-related quality control</td>
<td>Guidance technology</td>
<td>Radiation technologist</td>
</tr>
<tr>
<td>Pretreatment image guidance</td>
<td>Linear accelerate</td>
<td>Medical physicist</td>
</tr>
<tr>
<td>Dose delivery</td>
<td>$^{60}$Co unit</td>
<td>Service engineer</td>
</tr>
<tr>
<td>On-treatment care</td>
<td></td>
<td>Radiation oncologist</td>
</tr>
<tr>
<td>Ongoing follow-up</td>
<td></td>
<td>Nurse</td>
</tr>
<tr>
<td>Follow-up</td>
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</tr>
</tbody>
</table>

### Implementation challenges
- Quality and safety
- Local regulations
- Adapting guidelines
- Role of each RT professional

Increasing access to EBRT

- Co60 units
  - Lack of machine development?
  - Improved RT delivery achievable with Co60-based IMRT
  - Security issues

- Simpler LINACs
  - Development is proprietary
  - Removal of parts that require frequent repair
  - e.g., fixed-beam radiotherapy

Rodin D., et al. JTO 2015; 11: 21
Tele-Radiotherapy

Telementoring through tele-education: Capacity building of radiotherapy personnel

Coordinated by the United Nations Organizations—WHO, IAEA, ITU

Various professional societies  Universities and departments

Primary radiotherapy center  Secondary radiotherapy center

Datta N., et al. IJROBP 2016; 95: 1334

Coordinated knowledge transfer
Tele-Radiotherapy

› Remote planning
› Automated quality assurance

Datta N., et al. IJROBP 2016; 95: 1334
Artificial intelligence in Global RT

- Alleviate workforce shortages
- Access to knowledge and experience across disease sites
- Impact on hardware shortages?

Summary

› LMICs are driving the increase in the incidence of LC worldwide

› Global access to RT for LC must be tackled at many levels
  › Healthcare systems
  › Hardware shortages
  › Human resources

› Research and innovation to ↑↑ access to RT for LC
  › Implementation and adaptation
  › Global clinical trials
  › Education
Resources

- IARC - GLOBOCAN
- Abdel-Wahab M., et al. JCO Glob Oncol 2021; 7: 827
- Rodin D., et al. JTO 2015; 11: 21
- Datta N., et al. IJROBP 2016; 95: 1334