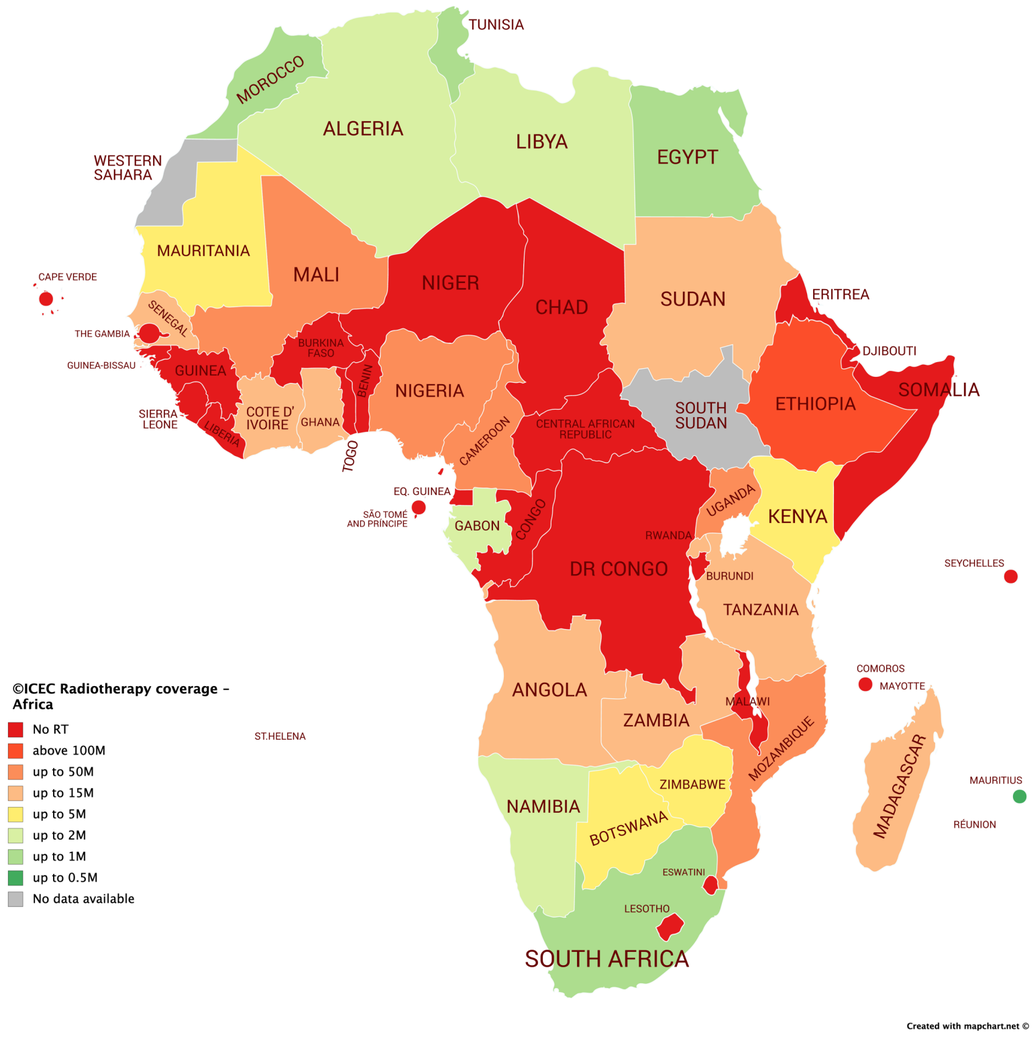
Ensuring Access to Nuclear Technology for Human Health



Linac-based RT coverage in Africa

Technology innovation to overcome the cancer care and radiological security challenges in Africa

Manjit Dosanjh, 17.02.2021

CERN

International Cancer Expert Corps
Partnering to transform global cancer care

UNIVERSITY OF OXFORD

Cancer is growing global challenge

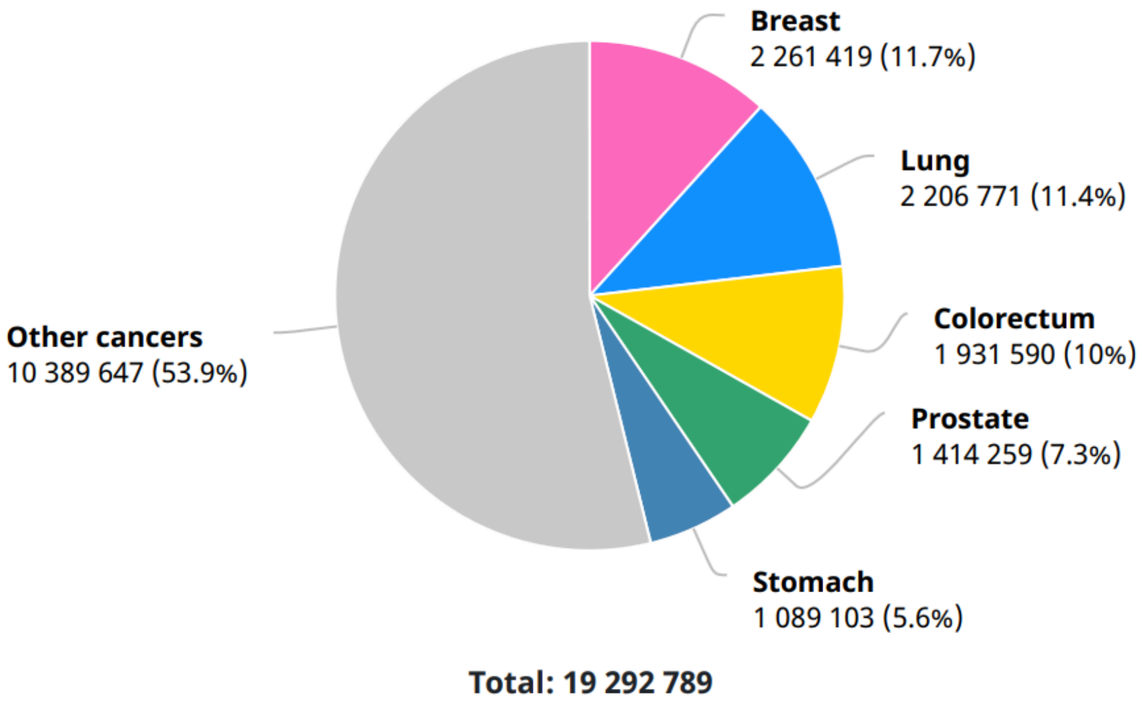
- Globally **18** million new cases per year diagnosed and **9.6** million deaths in **2018**
- Will increase to **27.5** million new cases per year and **16.3** million deaths by **2040**
- **70% of these deaths** will occur in low-and-middle-income countries (LMICs)

Radiation therapy is a key tool for treatment for over 50% patients and number of patients is increasing

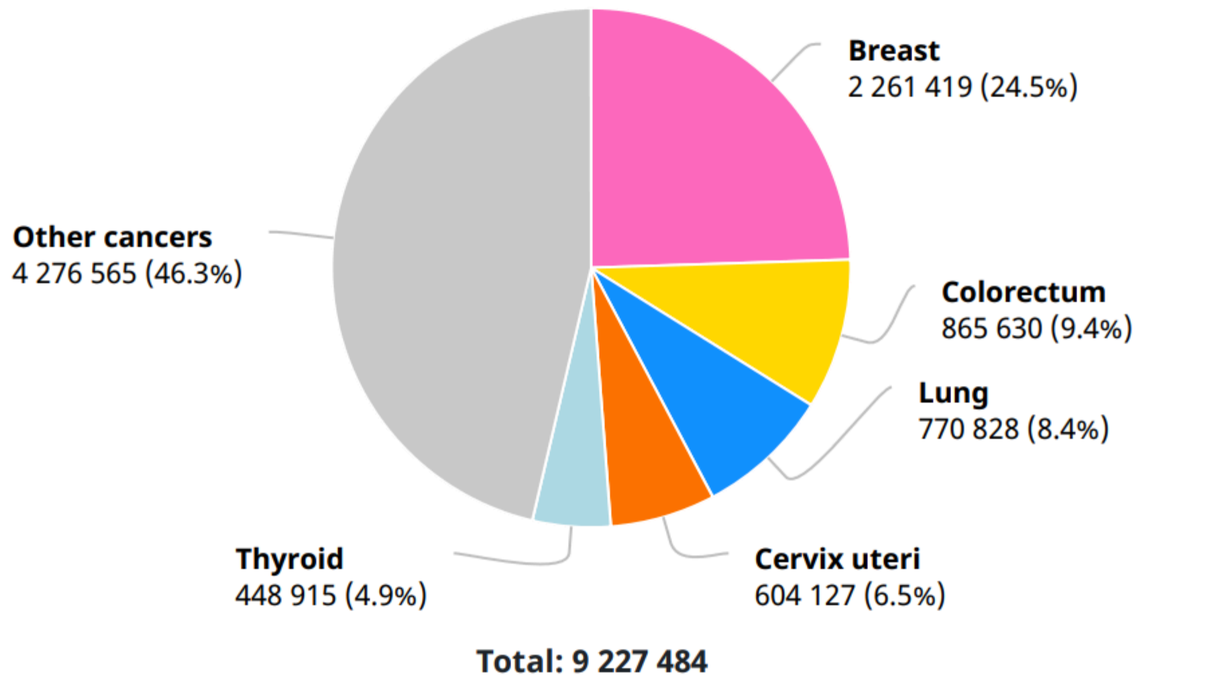
LMICs have limited radiotherapy access: **Only 10% of patients in low-income** and **40% in middle-income countries have access to RT**

GLOBOCAN 2020

Number of new cases in 2020, both sexes, all ages



Number of new cases in 2020, females, all ages



Every year, 2 million women worldwide are diagnosed with breast or cervical cancer:

- 7 of 10 breast cancer deaths occur in low-middle income countries
- 9 of 10 cervical cancer deaths occur in low-middle income countries

SDG Goals and Maternal mortality: These breast and cervical cancer deaths also have a huge impact on child mortality, for every 100 women about 14-20 children die

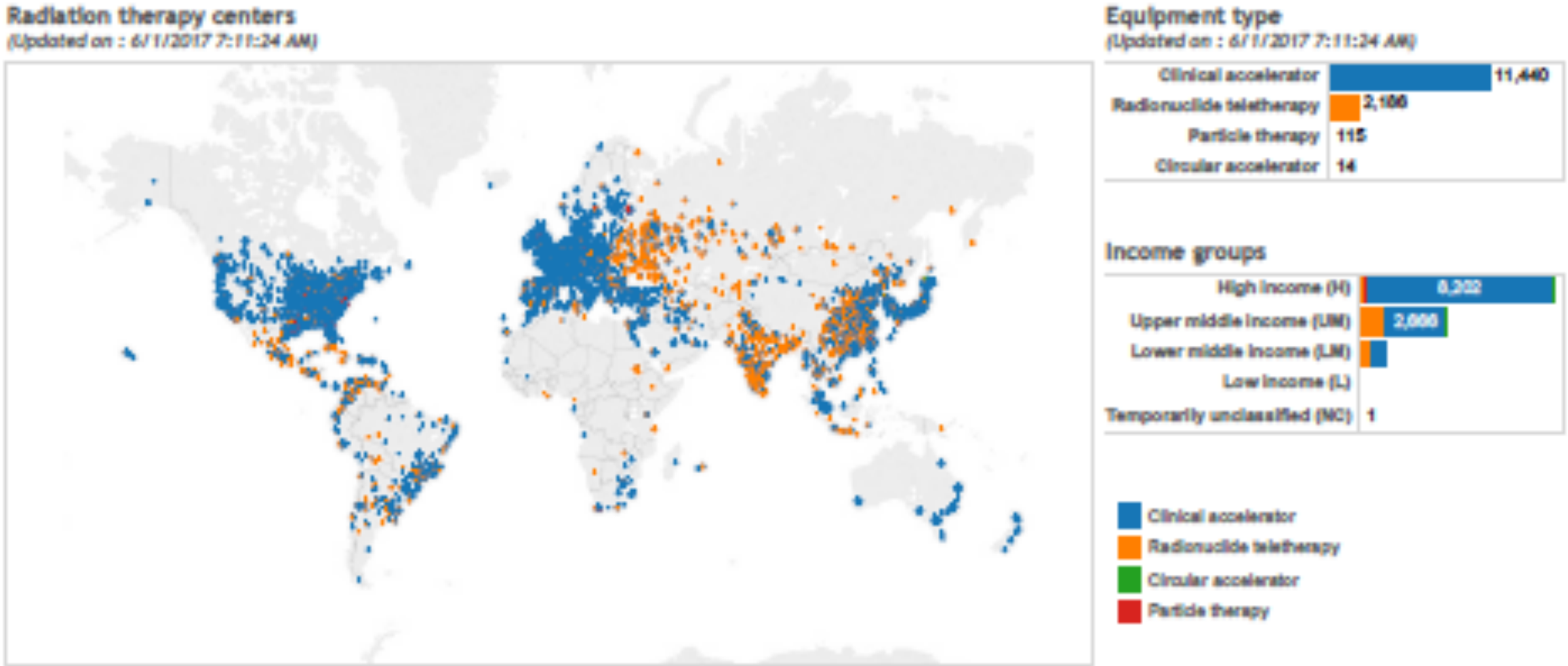
Estimating child mortality associated with maternal mortality from breast and cervical cancer

Raymond B. Mailhot Vega, MD, MPH[1,2]; Onyinye D. Balogun, MD[3]; Omar F. Ishaq, MD[1]; Freddie Bray, MD[4]; Ophira Ginsburg, MD[5]; and Silvia C. Formenti, MD[3]

Radiation Therapy is key tool treatment

- Cobalt 60 machines
- Linear accelerators (Linacs)
- Brachytherapy
- Image-guided radiotherapy (IGRT)
- MR-guided Linacs
- Particle therapy (proton and carbon)
- FLASH therapy (emerging technology)

World-wide radiotherapy coverage

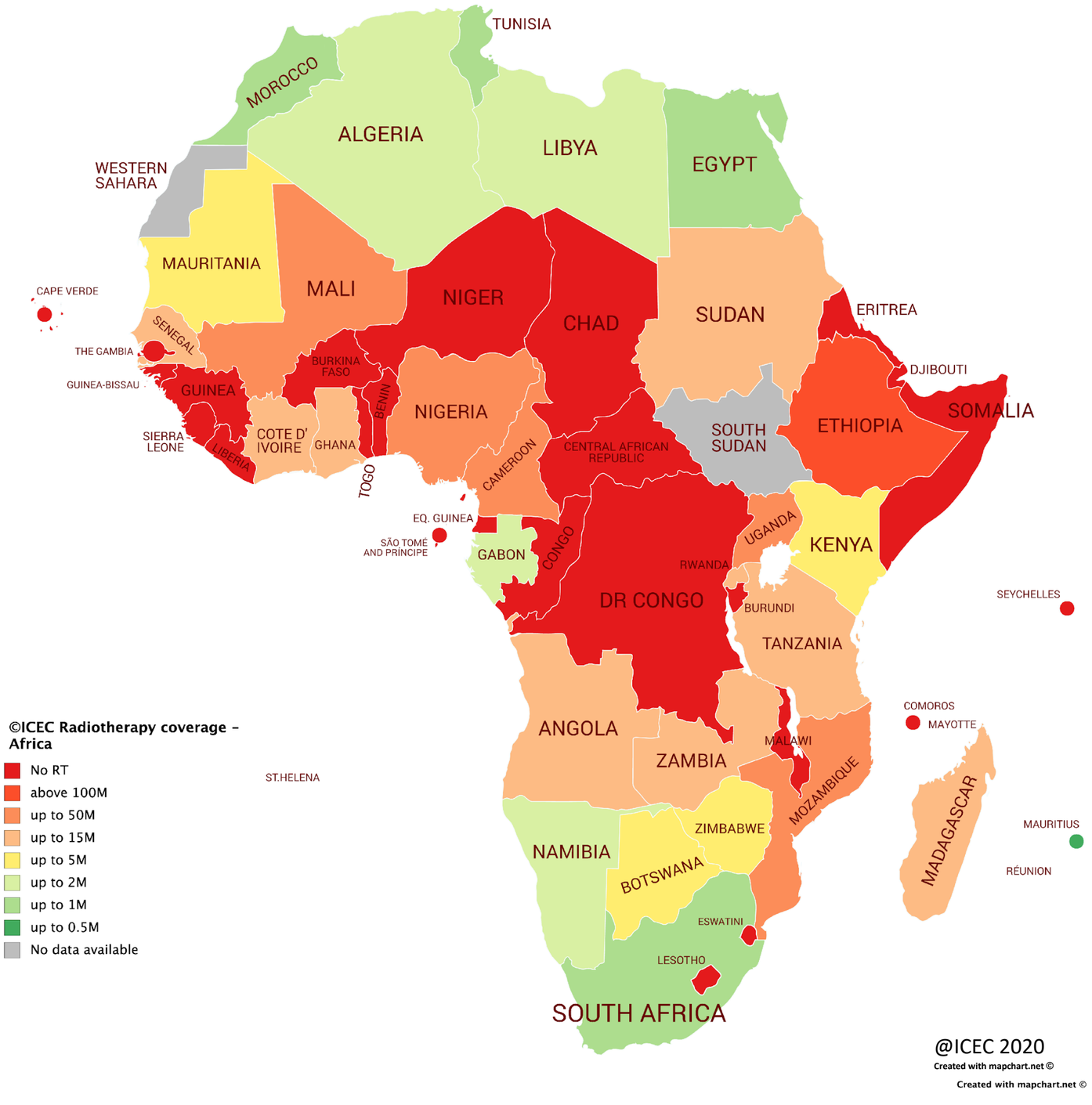


Countries	RT centers	Equipment	Linac	Radionuclide Therapy	Circular Accelerator	Particle Therapy
139	7041	13755	11440	2186	14	115

Map showing the number of people per functioning machine in countries in Africa

Dramatic Disparity in Access to LINACs

Country	LINACs	Population	People per LINAC
Ethiopia	1	115 M	115,000,000
Nigeria	7	206 M	29,400,000
Tanzania	5	59.7 M	11,900,000
Kenya	11	53.8 M	4,890,000
Morocco	42	36.9	880,000
South Africa	97	59M	608,000
UK	72	67.M	195,000
Switzerland	540	8.6 M	119,000
US	3827	331 M	87,000



- **28** countries have LINAC-RT facilities
- **12** countries only one facility
- **27** no LINACs for RT
- **385** RT-LINACs for > **1 billion** people
- **Nigeria** had 85 radiation and clinical oncologists and only a couple of trained linear accelerator maintenance engineers for its nearly 200 million people

Africa's Radiation Therapy Status

- **Acute shortage of RT** services both in quantity and quality
- **385 LINAC-**RT machines for more nearly **1.2 billion** inhabitants
- If current trends persist, GLOBOCAN forecast
  - By 2030, there will be **1.4** million new cases of cancer
  - and there will be **1** million deaths in Africa
- Only **28** countries have RT facilities **27** have none
- Over **60% located in just 3 countries**: South Africa, Egypt and Morocco
- **12** countries only one facility
- More than **18 countries** have Cobalt machines
- Africa has around **88 Co-60** machines (half of which are over 20 years old) proportionally more than any other continent
- Some of the **27 African countries lacking a Linac-RT** will consider buying Co-60 machine they are currently cheaper and easier to use

Treatment Comparison: Co and Linac machines

Characteristic	**Cobalt**	**Linac**
Penumbra of photon beam	Large due to physical size of Co source	Small
Radiation dose distribution from machine to tumor	Less well formed	well-defined radiation dose distributions from
Energy of photons from machine	Low (1.17 and 1.33 MV), produce max radiation dose at depth of 0.5 cm in tissue	High (6 MV), produce max rad dose at depth of 1.5 cm in tissue
Patient treatment capacity	Dose rate decreases by half every five years, treatment time doubles	does not decrease with time

Cost and Operational Needs

Cobalt-60	Linac
Widely used for treatment in poorer countries	Have greater infrastructural demands
Less costly	Require stable power grid and access to clean water
More reliable in challenging environments	Power interventions include: battery backups, solar arrays, diesel generators
Locally available spare parts	Higher operational costs
Lower operational and maintenance cost	Necessary service and maintenance contracts are costly
Less down time	Enough spare parts are not on hand
Available engineers locally	Downtime can range from weeks to months

Co-60 Machines

- Recent problem: there is a large expense associated with the return of used, but still highly radioactive sources, to their manufacturer, which should occur about every six years
  - often not included in the initial purchase price

- Many LMIC countries have legacy sources
  - lack adequate disposal facilities, or
  - they simply cannot afford to return disused sources,
  - leaving them vulnerable to theft or loss, security issue

LINAC-based Machine

- X-ray beam from a LINAC can be programmed to deliver high radiation doses that conform more closely to the specific size, shape and location of a tumor in a patient's body

- LINAC's therefore minimizes the exposure of normal surrounding tissues and organs at risk

- No security risks with LINACs, but requires a reliable and more stable electricity supply, including air conditioning, to operate

Current status

- The burden of cancer is increasing globally
- Large shortfall in LIC and LMIC RT systems that are needed for effective cancer care
- LINAC-based RT is the current technology of choice

But LINAC technology is **complex, labour intensive, and high cost** to acquire, install, operate and service.

Can we use technology developments to address the current challenges and make RT more widely available?

1st workshop on:
"Design Characteristics of a Novel Linear Accelerator for Challenging Environments"

Norman Coleman(ICEC) David Pistenmaa (ICEC) Manjit Dosanjh (CERN)

http://indico.cern.ch/event/560969/

European Organization for Nuclear Research (CERN)
International Atomic Energy Agency (IAEA)
James Martin Center for Nonproliferation Studies (CNS)
National Aeronautics and Space Administration (NASA)
National Nuclear Security Administration (NNSA)

Medical Linacs for challenging environments

- 1st Design Characteristics of a Novel Linear Accelerator for Challenging Environments, November 2016, CERN
- 2nd Bridging the Gap Workshop, October 2017, CERN
- 3rd Burying the Complexity Workshop, March 2018, Manchester

- 4th Accelerating the Future Workshop, March 2019, Gaborone

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Questionnaire

- We asked the **range of** questions
- Questions included the LINAC model, local environment, availability of services, subsystems, treatment and imaging.
- Which factors are responsible for machine downtime?
- Input for future machine

Received input from all African countries that have LINAC-based RT

Thank you to Dr Taofeeq Ige, Nigeria

This work would not be possible without the great collaborators:

- http://www.iceccancer.org/
- Thank you to **Taofeeq Ige** for leading data gathering in Africa and **Hubert Foy** who made the first contacts

Thank you for listening