Present and Future of Radiation Therapy in LMICs

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My background:

- I completed my clinical training in October 2005
- Worked at iThemba LABS for two years
- Then spent 9 years at Groote Schuur Hospital
- At Tygerberg Hospital since Feb 2017

- No conflict of interest to declare

Tygerberg Hospital

- Tertiary hospital in Cape Town, opened in 1976
- 1386 beds

Medical Physics in South Africa

1.22 M km^2 (471.000 sq miles)
~58 M people
9 provinces, 11 official languages

Classified as Upper Middle Income Country

Large inequality

- 2015: 71% of net wealth held by 10% richest of the population
- 60% of the poorest hold 7% of net wealth
- About a quarter of the population lives on <1.25 USD /day

- ~17% of SA population has access to private healthcare, but private sector accounts for about half of all SA healthcare expenditure and employs 70% of healthcare specialists

2015 study on licensed imaging equipment

- Only three provinces have the full spectrum of imaging modalities
- General radiography: 34.8 units / million
- Fluoroscopy: 6.6 / million
- Mammo: 4.96 / million
- CT: 5.0 / million

- Discrepancy 11-fold between best and least-resourced province
- Discrepancy 13-fold between private and public sectors.

- MRI: 2.9 / million (46-fold discrepancy btw private and public sectors)

Background

- From 1940's: Groote Schuur Hospital (Cape Town) started using radium sources, later also gold and tantalum, still have a well-established I-125 LDR (ophthalmic) brachytherapy programme

- Late 1940's: first orthovoltage units installed, first radionuclides imported
- 1958 or 1962: First Co-60 unit installed
- 1968: First linac in the southern hemisphere installed in Bloemfontein (12 MeV)

Regulation of Medical Physics

- As soon as the Atomic Energy Corporation became aware of the use of radiation in medicine, they started publishing regulations

- Hazardous substances act (1973) provides regulations for X-ray devices and radioactive substances
- Various regulations published
- Scope of medical physics profession published under Government Notice R310 in 1988
- Health Profession Act of 1974: all medical physicists must be registered by a professional board – HPCSA

- Currently: Regulator undergoing structural changes, severely understaffed

Education of Medical Physicists

- MP education seems to have started in the 1950's, because regulations from the Atomic Energy Board required "hospital physicists" to be registered from 1956

- → SA one of the first countries to regulate the profession

- Minimum requirement: BSc(Hons) in Medical Physics with a 2-year internship at an accredited training institution

Academic Training

- Six universities offer academic training (two of them re-established the programmes last year only), Bloemfontein starts the medical physics at undergraduate level already.

Clinical Training

- Training programmes accredited by the HPCSA every five years
- Seven institutions offer clinical training
  - 12 months in Radiotherapy
  - 6 months in Nuclear Medicine
  - 6 months in Diagnostic Radiology
- PoE, assessments, exit exam with external moderator
- Medical Physicist (Independent Practice) – not possible to register in one field only

Continuous Education

- 30 CPD / CEU points required per year for ongoing registration with HPCSA, including ethics points

Medical Physicists in SA (2019)

- 46 MPs appointed at the teaching hospitals
- Only two universities have academic appointments of MPs

- 28 interns undergoing training

Medical Physicists in SA (2019)

Table 3 Distribution of registered medical physicists in the public sector in South Africa

Medical Physicists	Total
Radiotherapy	33 + 1 x 5/8th
Nuclear Medicine	10.5
Radiology	9.5 + 1 x 5/8th
University appointed	6
Total	59 + 2 x 5/8th

Table 4: Distribution of registered medical physicists in the private sector and industry in South Africa

Medical Physicists	Total
Radiotherapy	51
Nuclear Medicine	2
Radiology	6
Metrology (SSDL)	3
Regulators	3
Industry and other	8
Total	73

SAAPMB

- 2 Feb 1960: the SA Association of Medical Physicists is founded by 8 medical physicists
- Now: South African Association of Physicists in Medicine and Biology

- Three societies:
- SAMPS
- SARPS
- SARS

- Membership: 119 full members, 71 associate/student/institutional/ retired/honorary members

Status in SA

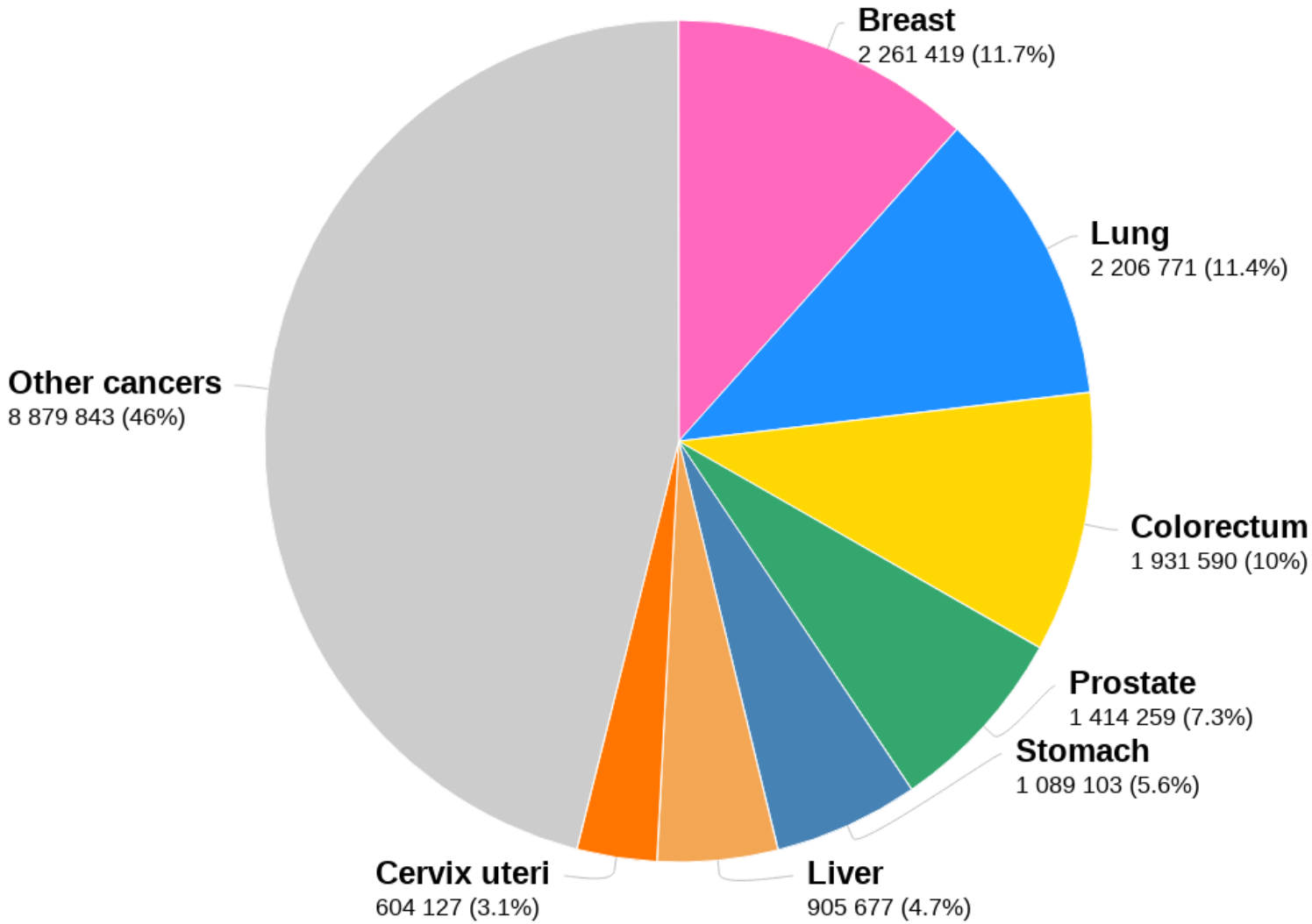
- There are some worrying signs (vacant posts not filled, severe problems at the regulator)

- There are a lot of young and enthusiastic medical physicists who are keen to take medical physics forward.

LMIC

- Worldwide access to radiotherapy is unacceptably low
- According to the WHO, cancer is the second leading cause of death globally, accounting for an estimated 9.6 million deaths, or one in six deaths, in 2018.
- 1 in 4 men and 1 in 5 women worldwide develop cancer during their lifetime
- 1 in 8 men and 1 in 11 women worldwide die from cancer

Estimated number of new cases in 2020, World, both sexes, all ages

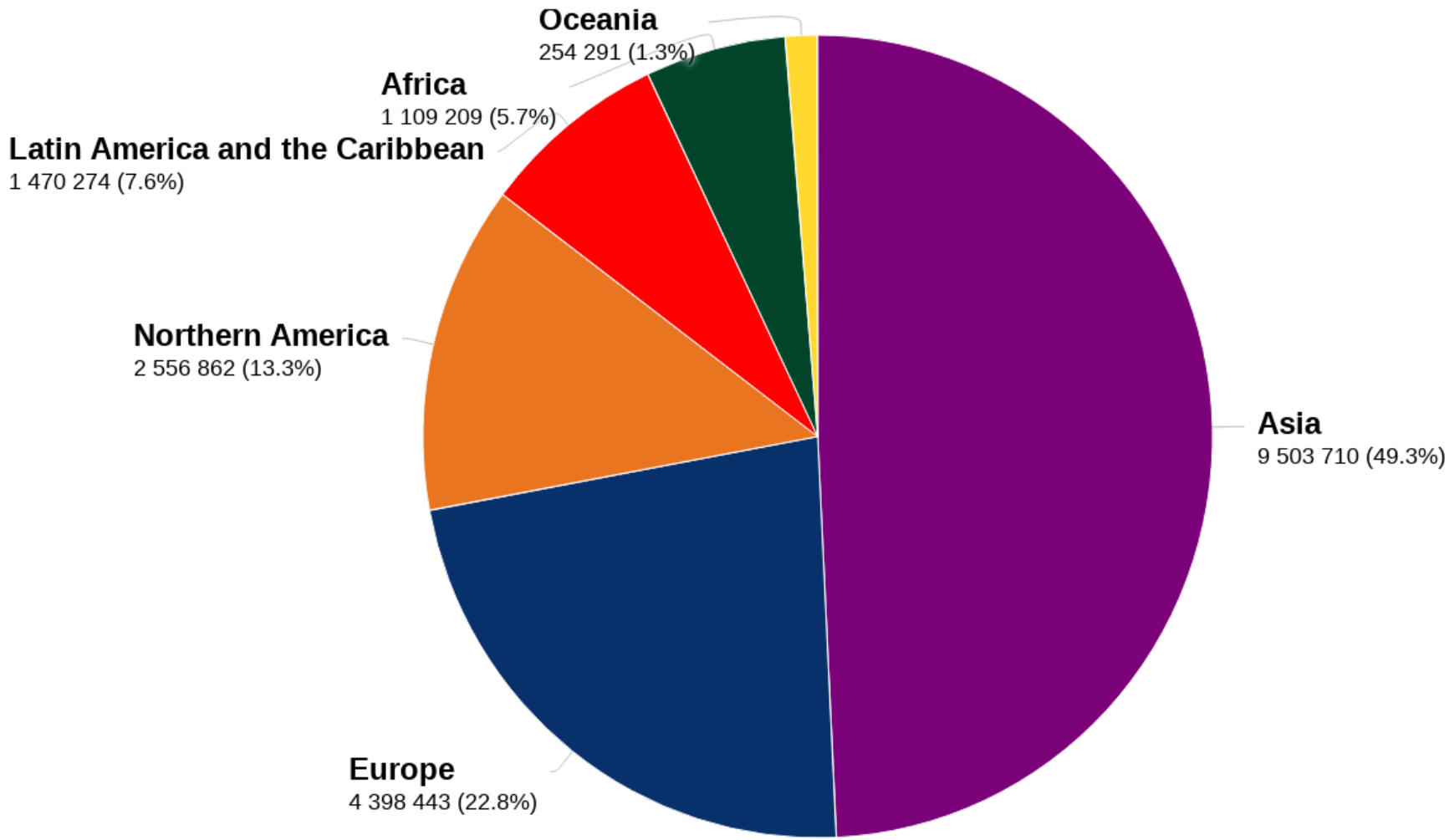


Total : 19 292 789

Data source: Globocan 2020
Graph production: Global Cancer Observatory (http://gco.iarc.fr)

International Agency for Research on Cancer
World Health Organization

Estimated number of new cases in 2020, all cancers, both sexes, all ages

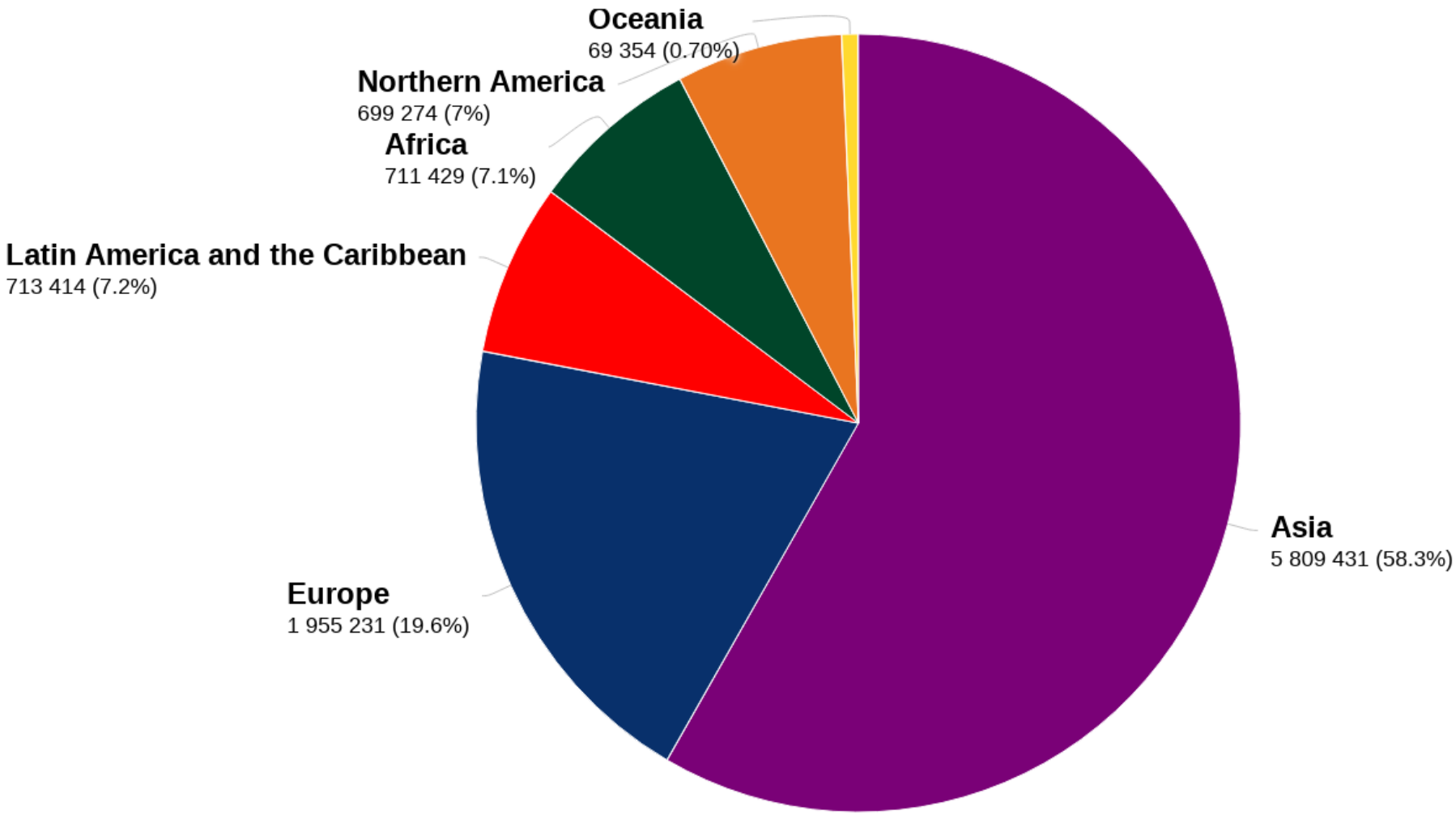


Total : 19 292 789

Data source: Globocan 2020
Graph production: Global Cancer Observatory (http://gco.iarc.fr)

International Agency for Research on Cancer
World Health Organization

Estimated number of deaths in 2020, all cancers, both sexes, all ages

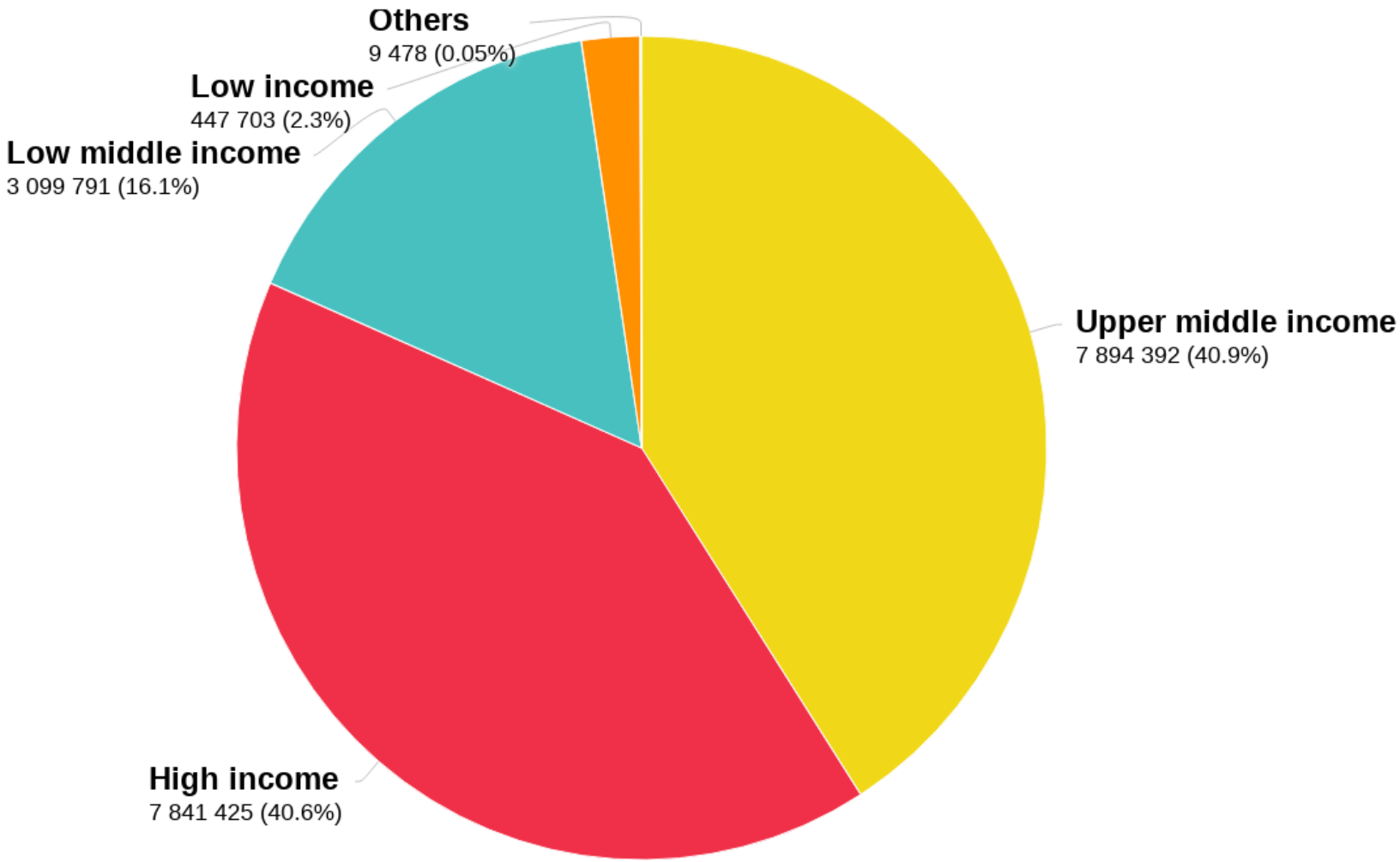


Total : 9 958 133

Data source: Globocan 2020
Graph production: Global Cancer Observatory (http://gco.iarc.fr)

International Agency for Research on Cancer
World Health Organization

Estimated number of new cases in 2020, all cancers, both sexes, all ages



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International Agency for Research on Cancer
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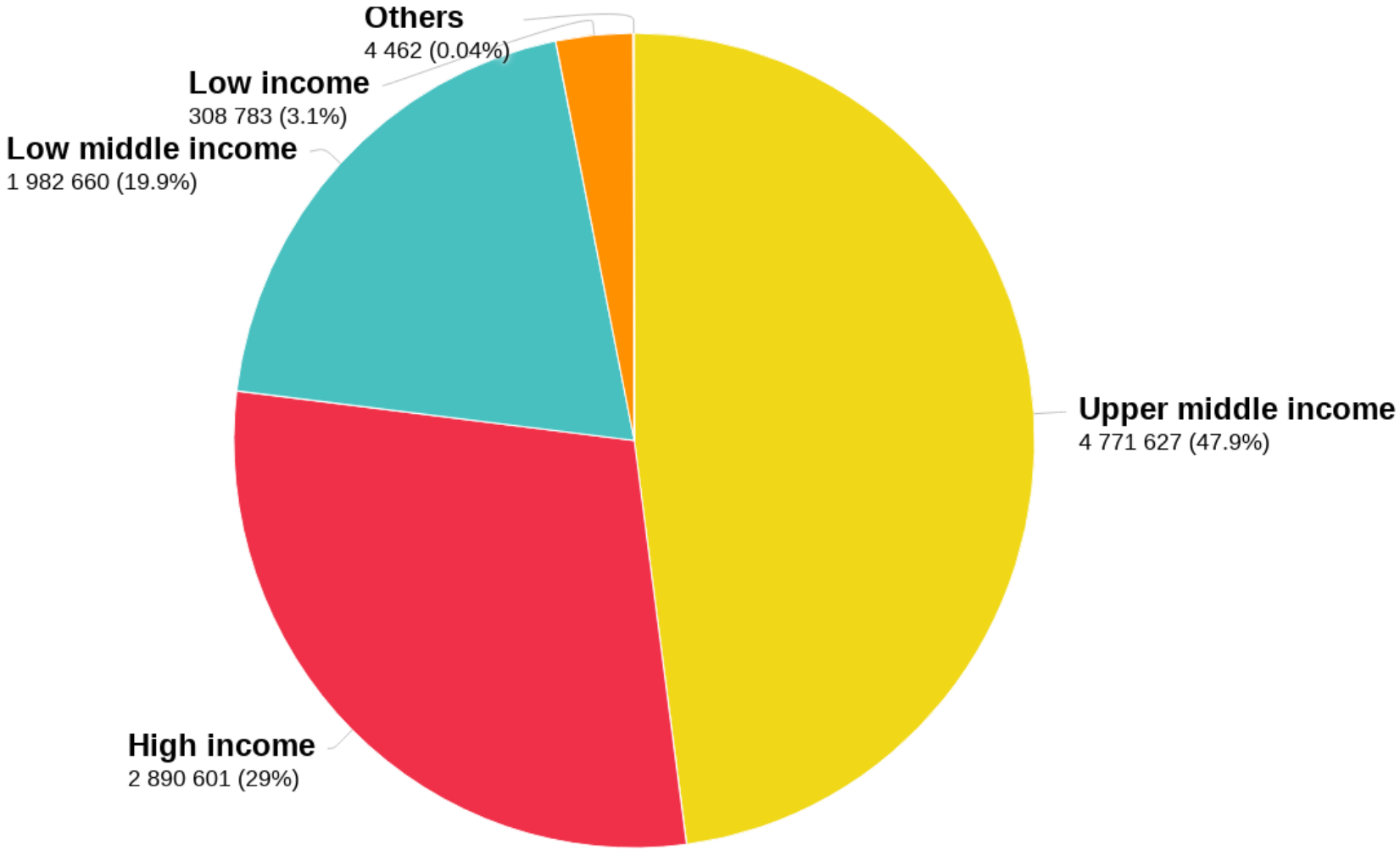


Total : 9 958 133

Data source: Globocan 2020
Graph production: Global Cancer Observatory (http://gco.iarc.fr)

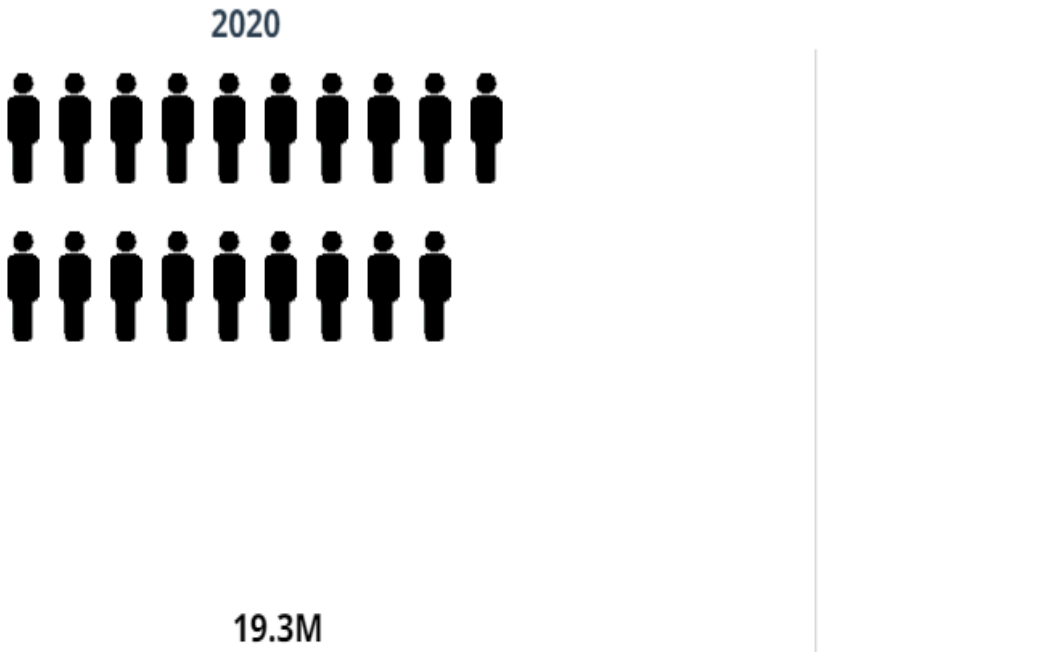
International Agency for Research on Cancer
World Health Organization

Estimated number of new cases from 2020 to 2040, Both sexes, age [0-85+]

All cancers

World

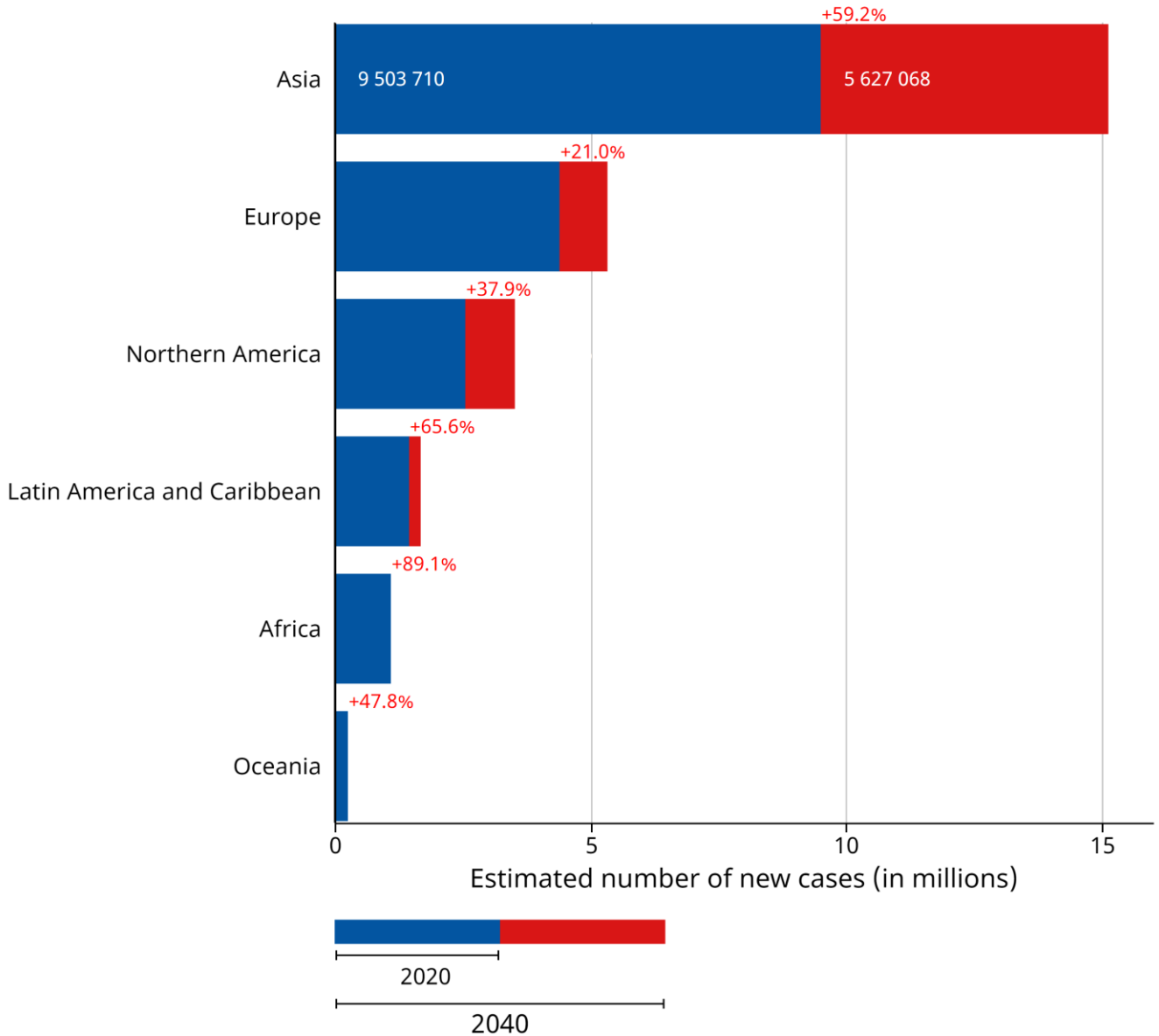
GLOBAL CANCER OBSERVATORY



International Agency for Research on Cancer
World Health Organization

Estimated number of new cases from 2020 to 2040, Both sexes, age [0-85+]
All cancers

GLOBAL CANCER OBSERVATORY

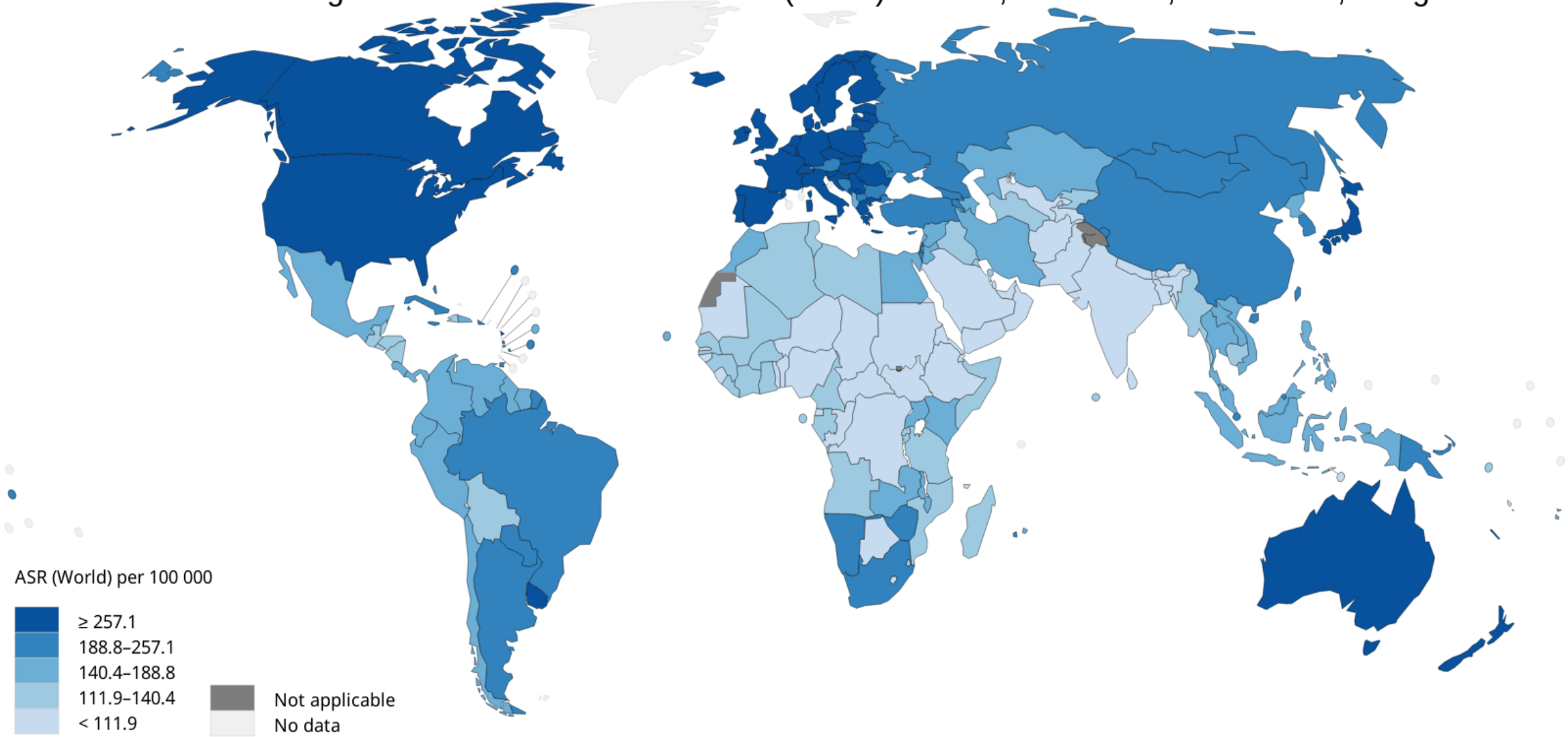


International Agency for Research on Cancer
World Health Organization

The global cancer burden is predicted to rise by almost 50 % between now and 2040

The biggest relative increase will occur in countries classified with a low HDI

Estimated age-standardized incidence rates (World) in 2020, all cancers, both sexes, all ages



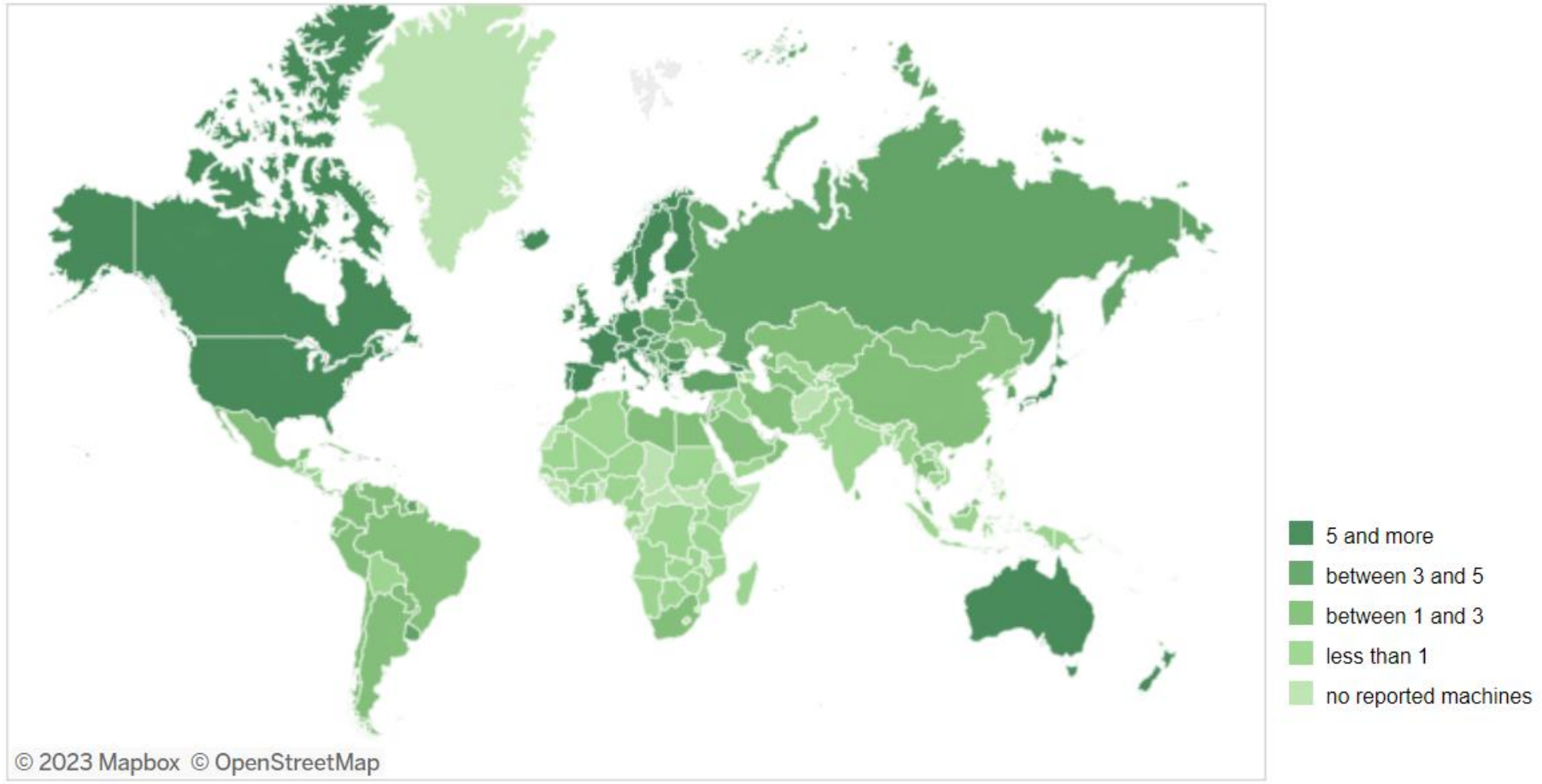
Data source: GLOBOCAN 2020
Map production: IARC
(http://gco.iarc.fr/today)
World Health Organization

Radiotherapy Resources

(all data from DIRAC database: https://dirac.iaea.org/)

Number of Radiotherapy Machines Per Million People

(Updated on : 3/9/2023 1:41:57 PM)



Status of Radiation Therapy Equipment

156 Countries

7814 RT Centres

15130 MV Therapy

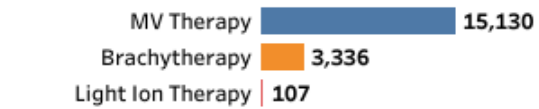
107 Light Ion Therapy

3336 Brachytherapy

Click on **Equipment type**, **Income groups** or **Regions** to create your own view. *Ctrl+click to select multiple items*

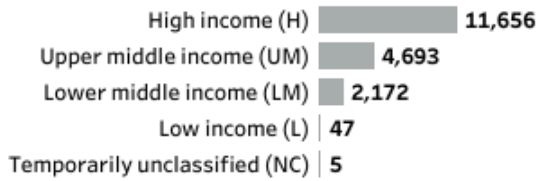
Equipment type

(Updated on : 3/9/2023 1:55:27 PM)



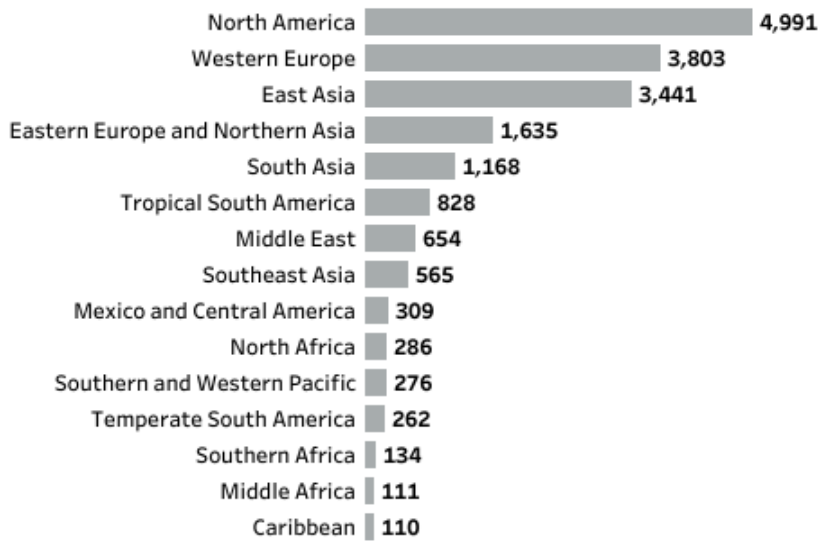
Equipment per income groups

(Updated on : 3/9/2023 1:55:27 PM)



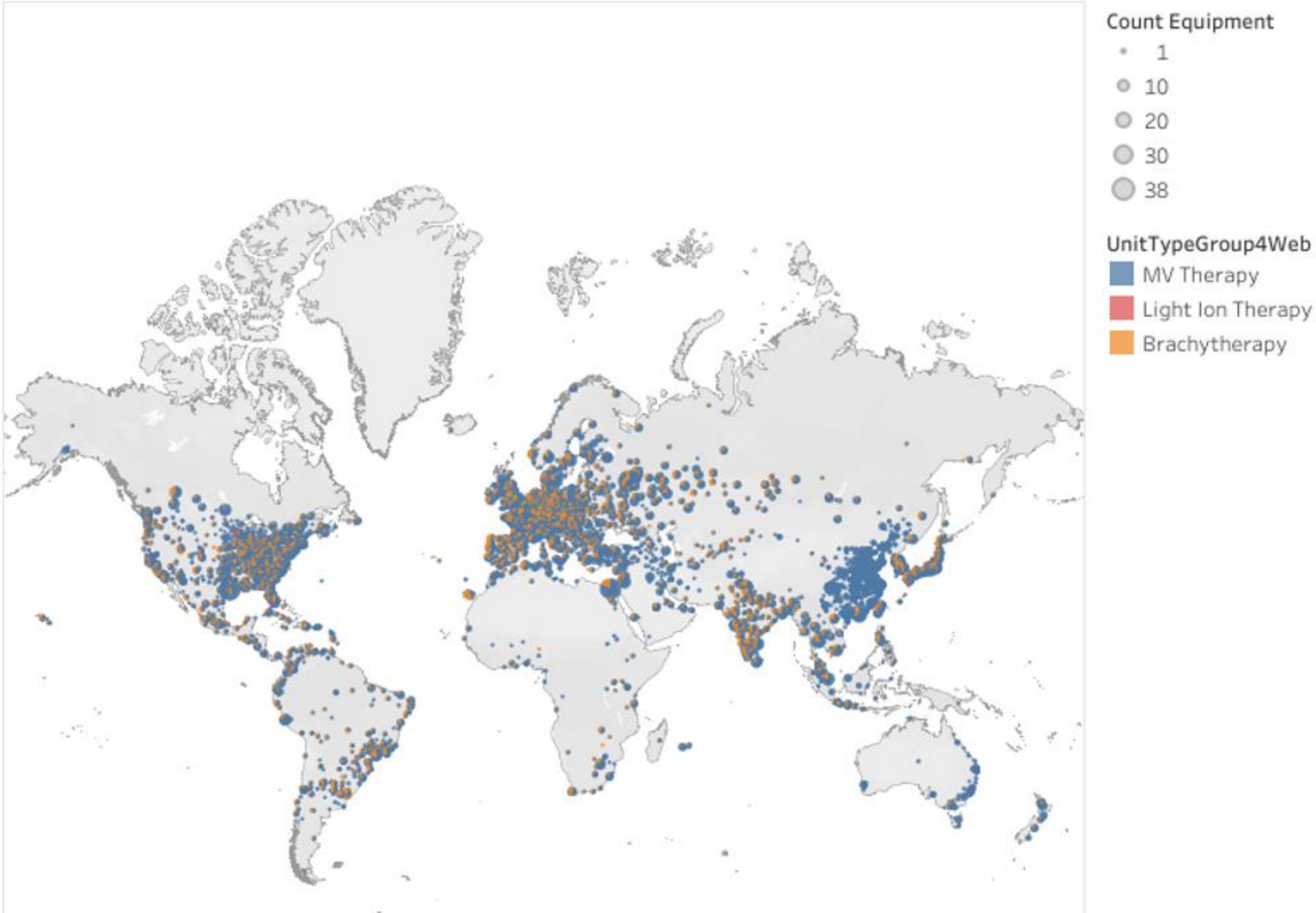
Regions WHO regions Country All

Equipment per regions

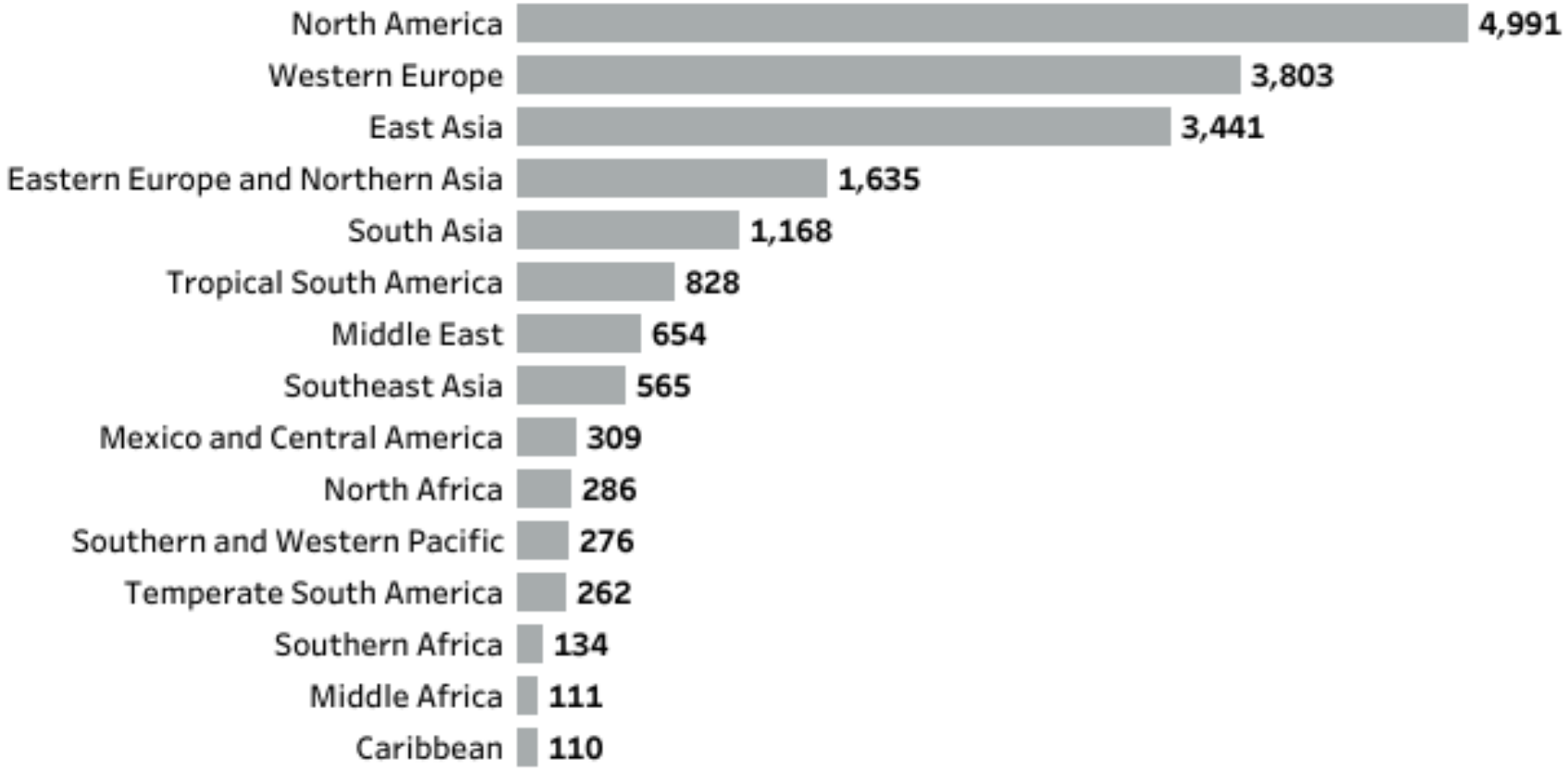


Radiation therapy centers

(Updated on : 3/9/2023 1:55:27 PM)



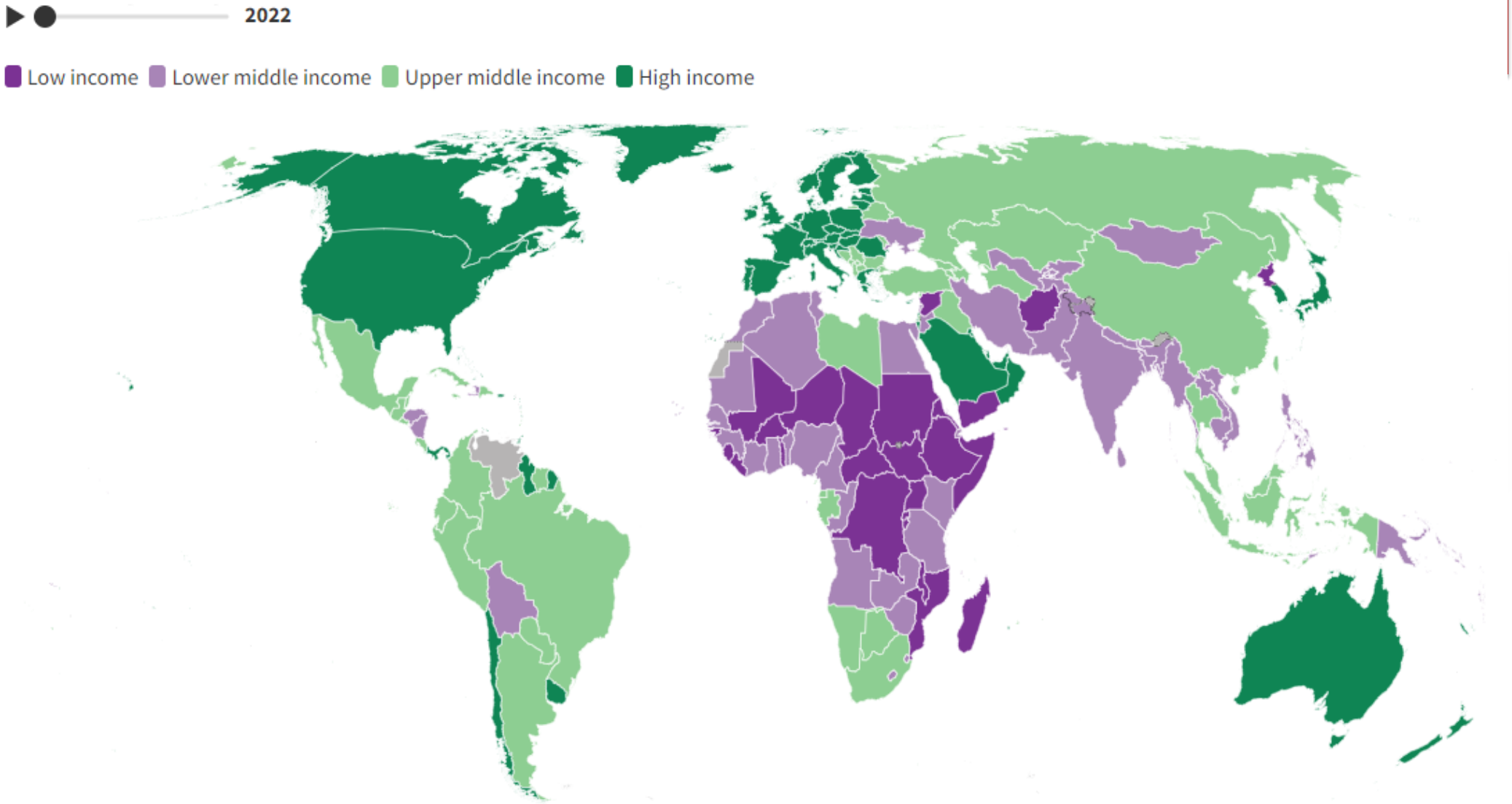
Equipment per regions



- 531 units in Africa (1.3 billion)

Region	Population [million]	No. of RT Equipment	Population per RT Equipment
Western Europe	196	3803	52000
USA + Canada	372	4991	75000
Latin/South America + Caribbean	666	1509	441000
East Asia	1662	3441	483000
Middle East	374	654	572000
Southeast Asia	666	565	1179000
South Asia	2032	1168	1740000
Africa	1467	531	2763000

The world by income



Source: World Bank

LMIC according to the World Bank
worldbank.org

- Low income: GNI per capita: <USD 1045

- Lower middle income: GNI per capita: USD 1046 – 4095
- Upper middle income: GNI per capita: USD 4096 – 12695

- Middle income countries are home to 75% of the world's population and 63% of the world's poor

Challenges

- Training curriculum for RO / MP/ RTT not harmonized or non-existent
- Lack of legislative recognition for MPs
- Lack of regulatory infrastructures

Challenges (adapted from F Hasford)

- Infrastructure
- Technical and operational
- Accessibility
- Human resources
- Recognition & Legislation

Challenges

- Infrastructure
  - Low prioritization of radiation oncology relative to other health services
  - Challenges with implementation of cancer control programmes
  - Lack of coverage of cancer care under health insurance schemes in several countries
  - Inadequate radiotherapy facilities
    - Shortage of 5000 radiotherapy units in LMICs (Samiei, 2013)
  - Unstable electricity supply

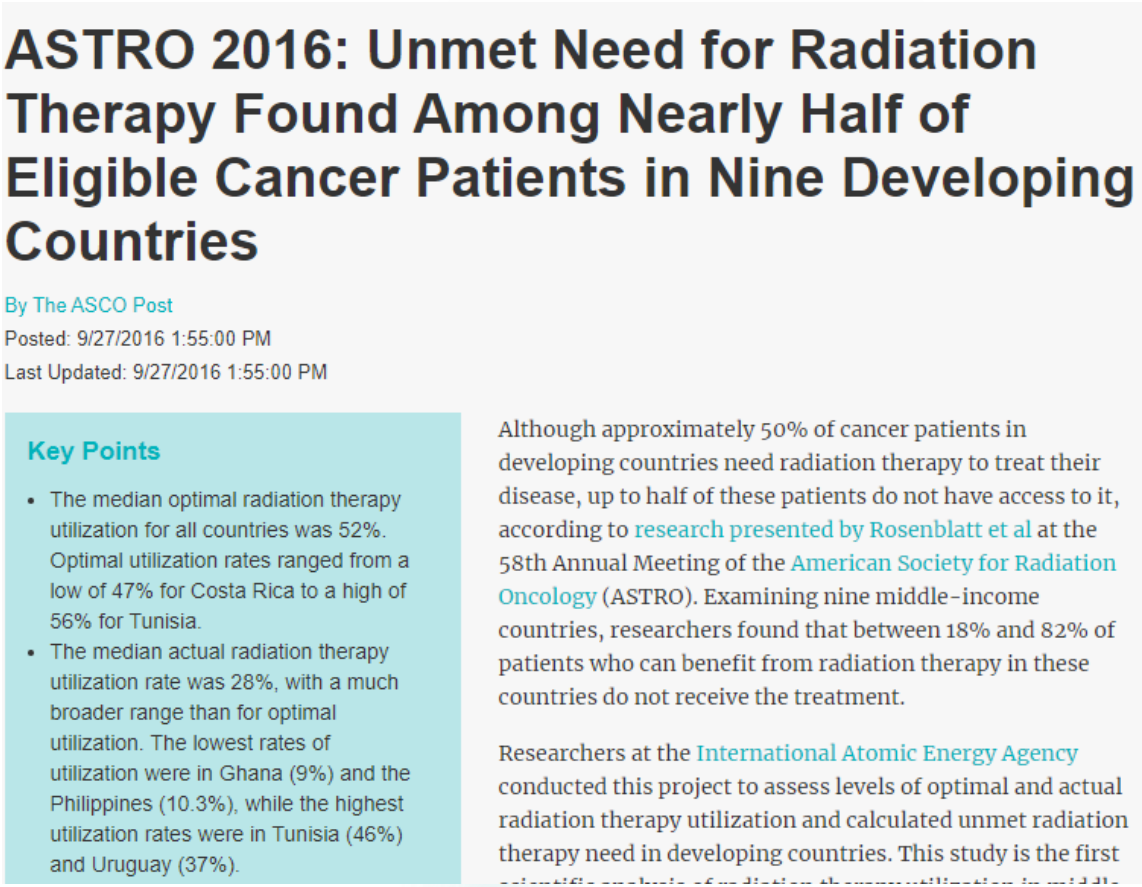
Challenges

- Technical and operational
  - Breakdowns of equipment lead to high downtime
  - Badly negotiated service contracts, or none at all
  - Not enough service hubs, spare parts take time to arrive
  - Lack of skilled service engineers

Challenges

- Accessibility
  - A significant number of countries have no access to radiotherapy (~ 20 in Africa)
  - Even if there is radiotherapy, it may not be accessible to large parts of the population
- Non-uniform distribution of resources
  - (example: South Africa and Egypt have ~50%
  - of resources in Africa)

(financial reasons, large distances, accommodation…)



ASTRO 2016: Unmet Need for Radiation Therapy Found Among Nearly Half of Eligible Cancer Patients in Nine Developing Countries

By The ASCO Post
Posted: 9/27/2016 1:55:00 PM
Last Updated: 9/27/2016 1:55:00 PM

Key Points

- The median optimal radiation therapy utilization for all countries was 52%. Optimal utilization rates ranged from a low of 47% for Costa Rica to a high of 56% for Tunisia.
- The median actual radiation therapy utilization rate was 28%, with a much broader range than for optimal utilization. The lowest rates of utilization were in Ghana (9%) and the Philippines (10.3%), while the highest utilization rates were in Tunisia (46%) and Uruguay (37%).

Although approximately 50% of cancer patients in developing countries need radiation therapy to treat their disease, up to half of these patients do not have access to it, according to research presented by Rosenblatt et al at the 58th Annual Meeting of the American Society for Radiation Oncology (ASTRO). Examining nine middle-income countries, researchers found that between 18% and 82% of patients who can benefit from radiation therapy in these countries do not receive the treatment.

Researchers at the International Atomic Energy Agency conducted this project to assess levels of optimal and actual radiation therapy utilization and calculated unmet radiation therapy need in developing countries. This study is the first

Challenges

- Human resources
  - Too few of everything
  - Often no posts at institutions
  - Often inadequate education and training programmes
  - Usually lower remuneration
  - Brain drain
  - ? Lack of harmonized syllabus (exists for MPs)

Challenges

- Recognition & Legislation
  - Registration of medical physicists as health profession workers
  - Lack of regulatory infrastructure

Only six countries have a legislative recognition of medical physicists

The Medical Physics Gap

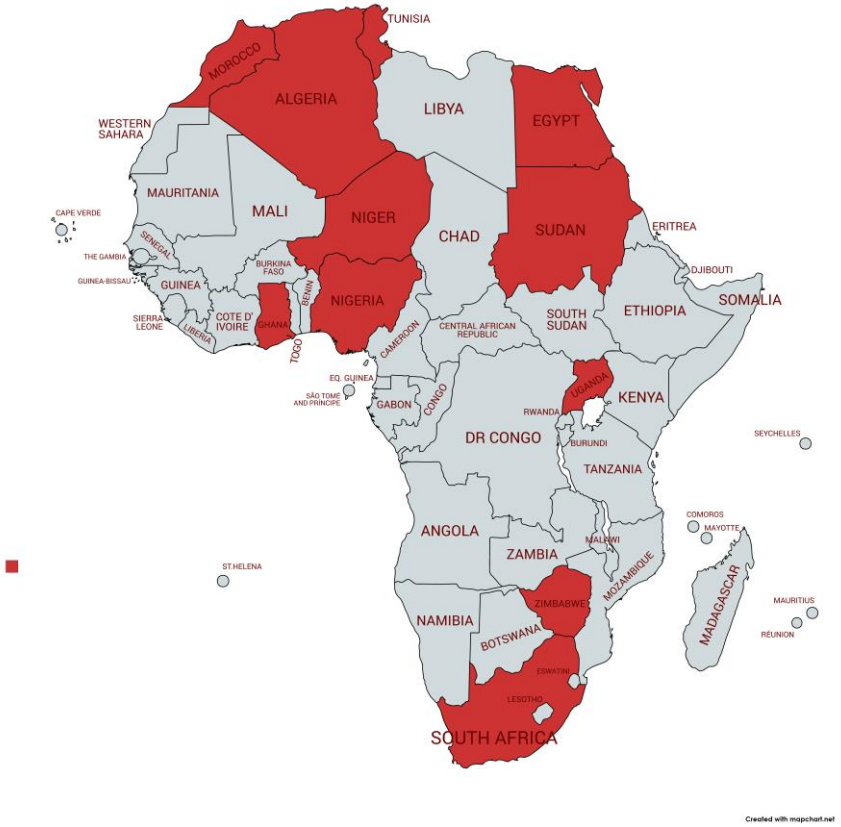
- Lancet Oncology (2015)
  - Projection: by 2035 in LMICs for radiotherapy we need 22.000 MPs
  - Call for Action: by 2025 in LMICs: 6.000 MPs to be trained

THIS IS IN TWO YEARS!

What can be done?

- National societies
- National cancer plans
- E&T – ICTP MMP for example
- Health service delivery: prioritization, policy, planning, processes, procedures

Only 11 countries have a national medical physics society



South Africa – 1960
Nigeria – 1986
Algeria - 1994
Morocco – 1996
Egypt – 1998
Sudan – 1999
Ghana – 2011
Tunisia – 2011
Niger – 2017
Uganda – 2019
Zimbabwe - 2020

Expanding global access to radiotherapy

Rifat Atun, David A Jaffray, Michael B Barton, Freddie Bray, Michael Baumann, Bhadrasain Vikram, Timothy P Hanna, Felicia M Knaul, Yolande Lievens, Tracey Y M Lui, Michael Milosevic, Brian O'Sullivan, Danielle L Rodin, Eduardo Rosenblatt, Jacob Van Dyk, Mei Ling Yap, Eduardo Zubizarreta, Mary Gospodarowicz

Lancet Oncol 2015; 16: 1153–86

Radiotherapy is a critical and inseparable component of comprehensive cancer treatment and care. For many of

	High-income countries	Upper-middle-income countries	Lower-middle-income countries	Low-income counties
Fractions	76 424 000	77 014 000	40 974 000	13 268 000
Radiotherapy departments	4600	3700	2000	600
Megavoltage machines	9200	7400	3900	1300
CT scanners	4600	3700	2000	600
Radiation oncologists to be trained	15 500	16 800	9900	3300
Medical physicists to be trained	17 200	12 500	7200	2400
Radiation technologists to be trained	51 900	45 300	24 900	8100

Data are n. The appendix contains more information about the CT scanner shared-use model.

Table 5: **Projected fractions and related resources needed in 2035**

Radiotherapy resources in Latin America and the Caribbean: a review of current and projected needs based on International Atomic Energy Agency data

May Elbanna, Yaroslav Pynda, Oleksandr Kalinchuk, Arthur Rosa, May Abdel-Wahab

The inequitable access to radiotherapy globally is a complex undertaking that will require sustained work identifying

Lancet Oncol 2023; 24: e376–84

- EBRT in 32 of 41 countries (742 centres, 1122 MV units)
- Co-60 decreased by 12% compared to 2018
- Current deficit in MV units estimated at 668 units and projected to be 2455 units by 2030
- "our data suggests there is at least a 15% improvement in EBRT capacity … when compared with 2018"

They identified:

- Insufficient investment in cancer control
- Non-universal health coverage
- Fragmented health systems
- Inequitable concentration of cancer services
- Inadequate registries
- Delays in diagnosis or treatment initiation
- Insufficient palliative services
- Difficulty in recruiting, training and retaining highly specialized staff

Cancer in sub-Saharan Africa in 2020: a review of current estimates of the national burden, data gaps, and future needs

*Freddie Bray, D Maxwell Parkin, on behalf of the African Cancer Registry Network**

Summary

Background With the cancer burden rising in sub-Saharan Africa, countries in the region need surveillance systems to

Lancet Oncol 2022; 23: 719–28

- Important to build capacity and infrastructure to inform local planning
- Computer based medical information systems remain underdeveloped in the region – all countries should aspire to a national cancer control plan

Radiotherapy resources in Africa: an International Atomic Energy Agency update and analysis of projected needs

Shekinah N C Elmore, Alfredo Polo, Jean-Marc Bourque, Yaroslav Pynda, Debbie van der Merwe, Surbhi Grover, Kirsten Hopkins, Eduardo Zubizarreta, May Abdel-Wahab

The number of patients with cancer in Africa has been predicted to increase from 844 279 in 2012 to more than 1·5 million

Lancet Oncol 2021; 22: e391–99

- "As of March 2020, 28 of 54 countries had access to external beam radiotherapy. 21 had brachytherapy capacity, and no country had a capacity that matched the estimated treatment need."

- "Urgent, novel initiatives in financing and human capacity building are needed…"

European Groundshot—addressing Europe's cancer research challenges: a *Lancet Oncology* Commission

Mark Lawler, Lynne Davies, Simon Oberst, Kathy Oliver, Alexander Eggermont, Anna Schmutz, Carlo La Vecchia, Claudia Allemani, Yolande Lievens, Peter Naredi, Tanja Cufer, Ajay Aggarwal, Matti Aapro, Kathi Apostolidis, Anne-Marie Baird, Fatima Cardoso, Andreas Charalambous, Michel P Coleman, Alberto Costa, Mirjam Crul, Csaba L Dégi, Federica Di Nicolantonio, Sema Erdem, Marius Geanta, Jan Geissler, Jacek Jassem, Beata Jagielska, Bengt Jonsson, Daniel Kelly, Olaf Kelm, Teodora Kolarova, Tezer Kutluk, Grant Lewison, Françoise Meunier, Jana Pelouchova, Thierry Philip, Richard Price, Beate Rau, Isabel T Rubio, Peter Selby, Maja Južnič Sotlar, Gilliosa Spurrier-Bernard, Jolanda C van Hoeve, Eduard Vrdoljak, Willien Westerhuis, Urszula Wojciechowska, Richard Sullivan

Cancer research is a crucial pillar for countries to deliver more affordable, higher quality, and more equitable *Lancet Oncol* 2023; 24: e11–56

- "a particular focus must be on central and eastern Europe, because our findings emphasise the widening gap in cancer research activity, and capacity and outcomes, compared with the rest of Europe."
- "our data highlight the important role of comprehensive cancer centers…"

More than 180 cancer registries in 30 countries

The Lancet Oncology Commission

Cancer in sub-Saharan Africa: a *Lancet Oncology* Commission

Wilfred Ngwa, Beatrice W Addai, Isaac Adewole, Victoria Ainsworth, James Alaro, Olusegun I Alatise, Zipporah Ali, Benjamin O Anderson, Rose Anorlu, Stephen Avery, Prebo Barango, Noella Bih, Christopher M Booth, Otis W Brawley, Jean-Marie Dangou, Lynette Denny, Jennifer Dent, Shekinah N C Elmore, Ahmed Elzawawy, Diane Gashumba, Jennifer Geel, Katy Graef, Sumit Gupta, Serigne-Magueye Gueye, Nazik Hammad, Laila Hessissen, Andre M Ilbawi, Joyce Kambugu, Zisis Kozlakidis, Simon Manga, Lize Maree, Sulma I Mohammed, Susan Msadabwe, Miriam Mutebi, Annet Nakaganda, Ntokozo Ndlovu, Kingsley Ndoh, Jerry Ndumbalo, Mamsau Ngoma, Twalib Ngoma, Christian Ntizimira, Timothy R Rebbeck, Lorna Renner, Anya Romanoff, Fidel Rubagumya, Shahin Sayed, Shivani Sud, Hannah Simonds, Richard Sullivan, William Swanson, Verna Vanderpuye, Boateng Wiafe, David Kerr

In sub-Saharan Africa (SSA), urgent action is needed to curb a growing crisis in cancer incidence and mortality. *Lancet Oncol* 2022; 23: e251–312

- "In the next 15 years, Africa is estimated to require at least 5000 additional megavoltage radiotherapy machines to ensure equity in cancer care"

Proposed actions:

- Precision cancer control planning
- Improving data acquisition and cancer registration
- Designing health care systems that promote equity of access
- Increasing cure and improving care
- Building and maintaining the workforce
- Innovation and research
- Invest in telehealth

Challenges to effective cancer control in China, India, and Russia

Paul E Goss, Kathrin Strasser-Weippl, Brittany L Lee-Bychkovsky, Lei Fan, Junjie Li, Yanin Chavarri-Guerra, Pedro E R Liedke, C S Pramesh, Tanja Badovinac-Crnjevic, Yuri Sheikine, Zhu Chen, You-lin Qiao, Zhiming Shao, Yi-Long Wu, Daiming Fan, Louis W C Chow, Jun Wang, Qiong Zhang, Shiying Yu, Gordon Shen, Jie He, Arnie Purushotham, Richard Sullivan, Rajendra Badwe, Shripad D Banavali, Reena Nair, Lalit Kumar, Purvish Parikh, Somasundarum Subramanian, Pankaj Chaturvedi, Subramania Iyer, Surendra Srinivas Shastri, Raghunadhrao Digumarti, Enrique Soto-Perez-de-Celis, Dauren Adilbay, Vladimir Semiglazov, Sergey Orlov, Dilyara Kaidarova, Ilya Tsimafeyeu, Sergei Tatishchev, Kirill D Danishevskiy, Marc Hurlbert, Caroline Vail, Jessica St Louis, Arlene Chan

Cancer is one of the major non-communicable diseases posing a threat to world health. Unfortunately, improvements

Lancet Oncol 2014; 15: 489–538

- Access to care, contamination of the environment, traditional medicine, affordability of care, provision of adequate health personnel, monitoring the cancer burden, effects of inequitable treatment and access to medicine

IAEA Rays of Hope

www.thelancet.com/oncology Vol 23 June 2022

- Launched in 2022 to help address the increasing cancer crisis
- Helps to build necessary infrastructure, procuring equipment, spurring research and educational innovation
- IAEA supports countries in creating frameworks, laws, procedures and training required

Where are we heading?

- Hypofractionation as a strategy propose
  - Leads to improved access, decreased number of machines, lower cost

Service quality critically affects cancer outcomes

- I foresee a massive increase in the use of Artificial Intelligence and machine learning in radiotherapy

- Automated contouring, treatment planning
- ? Who takes ownership and liability

Halcyon or similar

- Moves away from manual QC – daily MPC
- Moves away from substantial training requirements – just set the patient up straight

Co-60?

Daily adaptive radiotherapy

- On the high end of the spectrum – daily adaptive RT

Training for specific tasks only?

- Not convinced, but will speed up training period

- Thank you!