Chapter 28
Radiation Therapy in Arab World

Zeinab Elsayed, Issam Lalya, Hussain AlHussain, and Layth Mula-Hussain

28.1 Background

Radiation Oncology, medical oncology, and surgical oncology are the three main specialties of clinical oncology. Radiotherapy (RT) is an essential pillar of cancer treatment used with curative or palliative intent. It can also be used as a single treatment modality or combined with surgery and/or systemic therapy [2]. Approximately up to 60% of cancer patients receive RT during their course of illness [12]. RT is used with curative intent in about 40% of cases [6].

The League of Arab States, which was formed in 1945, has 22 countries spread over North Africa and the Middle East. These countries are collectively known as the Arab world and have more than 426 million inhabitants [13]. As per the World Bank economic categorization, four countries are Low-Income Countries (LIC), eight countries are Low-Middle Income Countries (LMIC), four countries are Upper-Middle-Income Countries (UMIC), and six countries are High-Income Countries (HIC).

Z. Elsayed
Ain Shams University, Cairo, Egypt
e-mail: z_elsayed@med.asu.edu.eg

I. Lalya
Cadi Ayyad University, Marrakech, Morocco
e-mail: i.lalya@uca.ma

H. AlHussain
King Fahad Medical City, Riyadh, KSA
e-mail: halhussain@kfmc.med.sa

L. Mula-Hussain (✉)
Ninevah University, Mosul, Iraq

Sultan Qaboos Comprehensive Cancer Care and Research Centre, Muscat, Oman
e-mail: l.mulahussain@cccrc.gov.om

H. O. Al-Shamsi et al. (eds.), *Cancer in the Arab World*,
https://doi.org/10.1007/978-981-16-7945-2_28

Cancer is overgrowing among Arab countries, and by 2030, it is expected that there would be a 1.8-fold increase in cancer cases in this region [4]. Eighty percent of the region's countries have national cancer policies, yet only 45% of the programs function [46, 47]. There is also low research outcome in this field, especially in the preventative cancer control policies [18].

28.1.1 Definition

Radiation oncology is a medical specialty that uses ionizing radiation (X-ray, Gamma-ray, Alpha and Beta particles) to treat malignant diseases and occasionally benign or functional diseases. Ionizing radiation damages cells' DNA and blocks their ability to divide further and proliferate [23]. RT aims to deliver high radiation doses to tumor volumes accurately while minimizing the amount received by surrounding healthy tissues [32]. A distinction must be made between the External Beam Radiation Therapy (EBRT), which is a technique using an irradiation source located outside the patient, most often coming from a linear accelerator, and the brachytherapy, which uses sealed sources placed either inside the target volume (interstitial) or on its contact in a natural cavity (endocavitary) or a duct (endoluminal).

28.1.2 Origin and Development

The discovery of X-rays was announced by Wilhelm Conrad Röntgen, a German mechanical engineer and physicist, on November 30, 1895 [38]. However, there is little doubt that X-rays were produced earlier by Julius Plücker, another German mathematician and physicist, who noticed in 1859 that the passage of a high voltage current through a vacuum tube produced an apple-green fluorescence on the inner wall of the tube. In 1875, Sir William Crookes noted that this apple-green light of Plücker's had its origin at the opposing end of the tube and therefore called this phenomenon the cathode ray [10]. The first therapeutic uses of X-rays in cancer followed its discovery by a few months [19].

Natural radioactivity was discovered by the physicist Antoine-Henri Becquerel while working with uranium salts in 1896. Shortly after that, Marie and Pierre Curie discovered radium and polonium, and in 1902, radium had been used to treat pharyngeal carcinoma. The concept of insertion of radium tubes into tumors (interstitial brachytherapy) had started in 1904 [9]. In the 1920s, Regaud and Ferroux from France established the biologic bases of fractionated radiotherapy [37].

Conceptual, technological, and radiobiological discoveries and innovations over the twentieth century lay the foundations for the safe and effective RT used today [9]. In the last three decades, RT has advanced amazingly, from 2D to 3D and then to Intensity Modulated Radiation Therapy (IMRT) and Stereotactic ABlative Radiotherapy (SABR) with many modalities in between [7].

28.1.3 Members of the Teamwork

28.1.3.1 Radiation Oncologist (RO)

RO is a physician who is a member of a multidisciplinary team (MDT) to treat cancer patients (and some benign diseases) using ionizing radiation [2]. RO should be certified by the appropriate certification board before practicing the specialty [34].

28.1.3.2 Medical Physicist (MP)

MP is a scientist who works closely with physicians, dosimetrists, and therapists and applies knowledge of radiation physics, radiobiology, and radiation safety to perform optimum, safe RT. In addition, MP performs routine Quality Assurance (QA) for radiation equipment and imaging systems and calibration, commissioning, and installation of new RT machines [2]. As per International Atomic Energy Agency (IAEA), "Clinically qualified MP is a physicist working in healthcare who has received adequate academic postgraduate education in medical physics and relevant supervised clinical training" [17].

28.1.3.3 Radiation Therapy Technologist (RTT)

RTT is a technician who uses physics, radiology, patient care, and patient safety to deliver therapeutic ionizing radiation to patients. In addition, RTT is trained and qualified to operate teletherapy machines [2].

28.1.3.4 Radiation Oncology Nurse

Radiation Oncology Nurses have a good overall understanding of general health, cancer medicine, and RT. They help with procedures such as brachytherapy, drug administration, clinical examination, and RT simulation. In addition, they support patients and their families during the treatment journey [2].

28.1.3.5 Radiation Machines Engineer

RT maintenance engineer is responsible for verification that the RT machine performs appropriately and according to both functionality and safety specifications [30].

28.2 History of Radiation Therapy in Arab World

Arab countries started building up radiation services, whether for diagnostic or therapeutic purposes, not far away from its inception. Some radiation machines were used as early as the first quarter of the twentieth century. In Iraq, the first establishment of radiation services was launched with a superficial X-ray therapy machine at the Radiology Institute in Baghdad during the 1920s [30]. In Lebanon, the Hotel-Dieu de France Hospital of the University of St Joseph opened its RT department in 1925. In Morocco, the history of radiotherapy dates back to 1929 by establishing the Bergonié center at the Averroes Hospital in Casablanca. In Egypt, the first RT unit at the Kasr Al-Ainy Hospital (Cairo University Hospital) was established in the 1930s. At that time, just as in other countries worldwide, radiation oncology did not exist as a separate specialty but was a part of the radiology, tumor management, and electrotherapy department at Cairo Faculty of Medicine [49]. Subsequently, RT departments further expanded and grew in other Arab countries.

28.3 Status of Radiation Therapy in Arab World

28.3.1 Human Resources and Treatment Facilities

Worldwide, gaps to RT access have been identified, not only in LMIC as expected, but also in Europe, as access to RT remains limited in many countries [1, 5, 11, 40]. Furthermore, a commonly used benchmark for RT machine availability of 450–500 patients per RT unit per year has been suggested for suitable machine throughput, whereas annual numbers of 200–300 patients per RO, 300–500 per MP, and 100–150 per RTT have also been suggested in several reports [35, 42, 44, 45].

The number of current RT machines in the Arab world was obtained from the Directory of Radiotherapy Centres (DIRAC) database, managed by the IAEA as of April 2021 [20], while population and new cancer cases per country were obtained from GLOBOCAN global cancer statistics 2020 [15]. Data from DIRAC shows that 18 out of the 22 Arab countries have RT facilities, while four countries (Comoros, Djibouti, Palestine, and Somalia) have no information on their facilities. Table 28.1 shows that in 2021, there are 364 Mega-Voltage Machines (MVMs) serving a total population of 427.8 million in 210 RT centers [20]. For the ideal need for MVMs, some equations can be used, similar to the one we mentioned in the previous paragraph. Although that this equation is valid, we think that group II of the World Health Organization (WHO) recommendations, by providing one MVM per one million population, can simply fit the minimal need of our people in the Arab world; However, if we have the facilities to move to group III WHO recommendation, by providing 2 MVMs per one million population, this might be optimal.

Table 28.1 RT status in Arab world countries as in 2021 based on the group II WHO recommendation of 1 MVM/million population

Arab countries	population	New cancer cases	Current MV machines	Ideal RT machines	Ratio of EBRT machine/ million population	Current Brachytherapy equipment	DIRAC data update
Egypt	104,047,786	134,632	120	104	1.15	23	2021
Algeria	44,588,410	58,418	37	44.6	0.83	12	2020
Sudan	44,709,056	27,382	10	44.7	0.2	2	2020
Iraq	40,948,473	33,873	23	40.9	0.56	2	2021
Morocco	37,287,724	59,370	43	37.3	1.15	10	2021
KSA	35,317,914	27,885	34	35.3	0.96	9	2021
Yemen	30,403,164	16,476	1	30.4	0.03	–	2018
Syria	17,299,112	20,959	10	17.3	0.57	2	2020
Somalia	15,893,219	10,134	No information				
Tunisia	11,933,090	19,446	25	11.9	2.1	4	2021
Jordan	10,353,556	11,559	13	10.3	1.26	1	2021
UAE	10,028,579	4,807	6	10	0.6	1	2020
Libya	6,960,374	7,661	6	6.9	0.87	1	2020
Lebanon	6,849,023	11,589	20	6.8	2.94	3	2020
Oman	5,249,890	3,713	2	5.2	0.38	1	2019
Palestine	5,203,412	4,779	No information				
Mauritania	4,756,163	3,079	2	4.7	0.43	1	2019
Kuwait	4,336,507	3,842	5	4.3	1.16	1	2021
Qatar	2,925,692	1,482	3	2.9	1.0	1	2019
Bahrain	1,779,580	1,215	2	1.8	1.11	–	2018
Djibouti	1,000,651	765	No information				
Comoros	885,582	609	No information				

Some Arab countries have comprehensive cancer and research centers, which are gradually becoming more popular, such as the King Hussein Cancer Center in Jordan and the Sultan Qaboos Comprehensive Cancer Care in Oman. Besides the Cyberknife, the Gamma Knife, and the Gantry-based Stereotactic Radiosurgery Units in many Arab countries, Saudi Arabia is going to be the first Arab country to have Proton Therapy Particles through the Saudi Particle Therapy Center that is equipped with ProBeam Cyclotron linked to five treatment units, which is anticipated to start treating patients by 2022.

Cancer patients' data are extracted from 2020 GLOBOCAN, Global Cancer Observatory: Cancer Today, Cancer Today (iarc.fr) in April 2021. Equipment data are extracted from IAEA DIRAC (Directory of Radiotherapy centers [20], Division for Human Health: DIRAC (DIrectory of RAdiotherapy Centres) (iaea.org). Accessed in April 2021. Abbreviations: *MV* Megavoltage, *KSA* Kingdom Saudi Arabia, *UAE* United Arab Emirates.

28.3.2 Education, Training and Certification Programs

Radiation Oncology exposure in many Undergraduate Medical Schools in Arab countries is very limited to a lecture or two with a significant lack of orientation to this particular specialty in many of the Undergraduate Medical Education Curricula [28]. Radiation Oncology Residency Training Program is not one of the many medical specialties offered by the Arab Board of Health Specializations. However, some Arab countries offer national, well-structured radiation oncology training programs.

In Egypt for example, radiation oncology training can be either a pure radiation oncology program or combined with medical oncology training in a clinical oncology program, which is the most popular. Within these programs, candidates are awarded a Master of Science (M.Sc.) degree after 2–3 years of training and a Medical Doctorate (MD) after another three training years. The candidate must pass written, clinical, and oral exams for both degrees and prepare an academic medical thesis. In addition, the Ministry of Health offers a separate fellowship for radiation oncology and another one for medical oncology in a 5-year training program. The Egyptian Children's Cancer Hospital (57357) has already established a 1-year fellowship program in pediatric radiation oncology in collaboration with the Dana-Farber Cancer Institute and Massachusetts General Hospital, Boston, Massachusetts [49].

In Morocco, the teaching of radiation oncology dates back to 1984, with a well-structured program influenced by the curricula of French universities and centers such as Alexis Vautrin and Gustave Roussy Institute. Medical oncology was individualized as a separate specialty since 2004. Training centers are affiliated to the faculties of Medicine and Pharmacy, with six university centers in total and the Military Teaching Hospital Mohamed V in Rabat, and two private university hospitals in Rabat and Casablanca. The National Diploma of Specialty graduates candidates after 4 years of training toward the final specialty exam. In 2016, Morocco requested a national technical cooperation project (MOR6023 'Improving the Quality of Radiotherapy by Developing Human Resources Capacity through Harmonization of Clinical Training in Radiation Oncology') with the IAEA to support the improvement of quality of radiotherapy.

In Lebanon, Saint Joseph University Hotel Dieu de France Radiation Oncology Department has an established residency program in Radiation Oncology. This program consists of one year of training in the general medicine program, 3 years of training at the department, and one year of training in one of the partner departments in France like Institute Gustave Roussy, Villejuif. Moreover, the American University of Beirut also has the first, and only ACME-I accredited Radiation Oncology residency training program that consists of 1 year of preliminary training in either surgery, internal medicine, pediatrics, followed by a 4-year comprehensive radiation oncology training, similar to the United States. This is routinely followed by a fellowship in the center in Northern America, such as the University of Texas MD Anderson Cancer Center, Memorial Sloan Kettering Cancer Center, or other centers.

In Jordan, and since 2004, King Hussein Cancer Center is offering a structured 4-year competency-based program, recognized and accredited by the Jordan Medical Council. In addition, residents have the opportunity to spend 3 months of external training at one of the affiliated cancer centers in either the USA or the UK [25]. In Iraq, The Zhianawa Cancer Center in 2017 celebrated its first board-certified ROs from a 4-year program that launched in 2013, which started back to the 2-year diploma program in oncology and radiation therapy that began in Baghdad in 1984 [29]. In 2018, the Saudi Commission for Health Specialties launched a 5-years robustly structured Radiation Oncology residency and certification program with structure and content built and adapted learning from International Benchmarks, mainly of North American Institutions [41].

MPs in the Arab world graduate from science faculties but with minimal clinical training. They gain their experience from working in different radiation oncology centers and departments. For example, in Egypt, MPs are graduates of biophysics departments within the Faculty of Science in various universities. They receive elective clinical training in radiation oncology and/or clinical oncology departments during their undergraduate studies. To be specialized in radiation oncology physics, they should have at least two years of training in this field within specialized departments [22, 26, 49].

The approximate number of MPs in the Middle East was around 740 in 2017 [33]. In 2009, the Middle East Federation of Organizations of Medical Physics (MEFOMP) was established as a regional organization of the International Organization for Medical Physics (IOMP), initially with 12 participating countries [22, 26]. It has been considered as a milestone that paved the way to establish Medical Physics Associations/Societies in the Middle East countries where there was none before [33].

As regards RTTs in Arab countries, the training programs were limited till recently. Realizing the importance of having adequate qualified RTTs, and as a mandatory step to lower the dependence on foreign personnel, many universities started to establish certified programs in conjunction with cancer hospitals and centers [27]. For many years, RTTs graduated from specialized institutes after studying for two years post-high school graduation in Egypt. However, in recent years, the policy changed to establish specialized universities (both governmental and private) to award graduates a bachelor's degree after the 4-year program in radiographic sciences [49]. Faculty of Health and Rehabilitation Sciences at Princess Nourah University, Saudi Arabia, established in 2011 a 5-years bachelor's degree in Radiological Sciences with four separate tracks that include a dedicated path of Radiation Therapy Program. Another example from Saudi Arabia, College of Applied Medical Sciences, King Saud University, offers a Radiological Sciences Program established in 1979. Graduates are awarded bachelor's degrees and study specialized radiological subspecialties, primarily diagnostic backgrounds [8].

The region has benefited greatly from projects with international organizations such as IAEA, both on the governmental and institutional levels [29]. For example, the American University of Beirut Medical Center has a well-established sister institution-ship and collaboration with the University of Texas MD Anderson Cancer

Center and the Memorial Sloan Kettering Cancer Center, respectively. King Hussein Cancer Center succeeded in collaborating with many reputable international cancer centers, like MD Anderson Cancer Center, Princess Margret Hospital, St June Cancer Center, Sick Hospital Cancer Center, and Moffit Cancer Center, through partnership programs and collaborative agreements [24]. The Children's Cancer Hospital in Egypt (57357), through its outreach division, has successfully collaborated with many regional and international institutions and organizations like Dana Farber Cancer Institute, Joint Commission International (JCI), St. Jude Children's Research Hospital, among many others. Another example was from Tunisia when it implemented modern RT techniques in the Radiation Oncology department of Hannibal Clinic. This project collaborated between the clinic and IAEA and resulted in the first Linear Accelerator (LINAC) 3D conformal radiation treatment in June 2011 [14].

28.3.3 Practice and Licensing

Almost all Arab countries have some form of licensing for ROs, MPs, and RTTs. To be specialized in radiation/clinical oncology, physicians must complete postgraduate studies and training in the specialty field. They are awarded the title after passing a series of written, clinical and oral exams with or without preparing an academic medical dissertation [48] [29]. In Egypt, e.g., physicians who want to practice in this specialty should receive either an M.Sc. or M.D. from an accredited University or obtain the Ministry of Health Fellowship in Radiation Oncology [49]. In addition, all practicing oncologists should get their licenses from the Egyptian medical syndicate.

MPs in Arab countries are licensed based on reviewing their qualifications and not necessarily after passing relevant exams [29]. There are no national or regional certification boards in Middle East countries, however, the International Medical Physics Certification Board (IMPCB), in 2019 onward, started exams in some Arab countries (Saudi Arabia, Jordan, and Qatar), and an increasing number of institutions encourage their MPs to pass these exams [21]. MPs' qualifications in the regulatory bodies have positively impacted MPs' practice in different hospitals. An example is the Radiation Safety Law in Jordan that was implemented in 2015, through which Jordan's Energy and Minerals Regulatory Commission (EMRC) published various reports, including the "Quality Assurance Program for Hospital X-ray Generating Equipment" [29]. The situation for RTTs licensures is similar to MPs regarding certification and accreditation [29].

28.3.4 Professional Societies of Radiation Oncology

The common feature between all countries of the Arab world is the absence of professional societies dedicated to radiation oncology practice and research. Instead, the existing organizations federate all cancer specialists, including medical and surgical oncologists, for example, the Arab Medical Association Against Cancer (AMAAC) and many other national oncology and cancer societies in the Arab world. This fact is maybe the consequence of the limited number of Arab radiation oncology practitioners, not allowing the creation of solid and well-structured societies. Added to this, a permanent feeling of dependence on foreign radiation oncology societies, given the quality of their scientific production, such as good practice guidelines and websites of e-learning and contouring.

In recent years we have seen the development of institutions that will certainly lead in the long term to well-organized societies. For example, the Iraqi Society of Radiation Oncology in 2014 arranged the Best of ASTRO meetings (officially licensed by the American Society of Radiation Oncology—ASTRO) in 2015 in Iraq [29], which was followed by the first Joint Conference Best of ASCO and Best of ASTRO the following year in 2016, in Egypt. The Saudi Assembly of Radiation Oncology was established in 2018 as a National Radiation Oncology Professional Community Group of Practice, and the National College of Radiation Oncology Professors in 2020 in Morocco with the sole mission of unifying the radiation oncology teaching program in Morocco, as well as the harmonization of practices. The most significant step would be to create a regional big society, from the MENA region, or ideally from the whole Arab world.

28.3.5 Research in Radiation Oncology

Scientific research in radiation oncology in the Arab world is limited to participation in the enrollment of patients for international multicentric randomized trials and the publication of treatment planning and dosimetric studies in high indexed journals.

In Morocco, the Institute of Research in Cancer was created in 2014 by the Lalla Salma Foundation, the Ministry of Higher Education and Scientific Research, and the University Sidi Mohamed Ben Abdellah in Fes. Among research laboratories affiliated with this institute, there is a nuclear physics laboratory whose activity is still rudimentary.

Radiation Oncology research activity in Saudi Arabia has gained momentum in terms of volume and international collaboration over the period from 2010 to 2019; however, the resulting level of evidence has not improved over time, which calls for an effort to contribute to the literature as a priority, allocate adequate resources, and apply appropriate measures to enhance research productivity and quality [3].

The basic research unit, the clinical trials unit, and the biobank at the Egyptian Children's Cancer Hospital 57357 facilitate high-quality research through efficient coordination and successful implementation of basic research and clinical trials in collaboration with international pediatric cancer centers, which resulted in many international publications in the field of pediatric radiation oncology.

28.3.6 Pediatric Radiation Oncology

RT is an essential part of childhood cancer treatment. However, the presence of a dedicated pediatric cancer center/hospital in Arab countries is uncommon. Most Arab countries have centers that treat both adults and pediatric patients or pediatric oncology departments within hospitals. A unique example of a specialized pediatric cancer hospital is the Egyptian Children's Cancer Hospital (57357). It was established in 2007 and was inspired by the St. Jude Research Hospital model in Memphis, Tennessee, in the USA. In addition to the Egyptian people, many Arab countries have contributed generously to make it one of the largest hospitals in capacity (320 beds). The King Fahad National Centre for Children's Cancer and Research is the only standalone children's cancer center in Saudi Arabia.

28.4 Future of Radiation Therapy in Arab World

28.4.1 Overcoming the Challenges

RT is an essential component of effective cancer treatment, yet the worldwide availability of RT facilities is unacceptably low [5]. Twelve of the 22 countries are classified as LMIC or LIC, according to the World Bank. These countries face the same challenges as other LMIC worldwide. As shown by [27], the availability of RT facilities was significantly influenced by economic status and correlated positively with GDP per capita. Based on group II WHO recommendations of at least one MVM/million population as a minimum supply, the Arab countries need about 427 MVMs to be in a minimally acceptable situation [36]. According to the most recent DIRAC data (Table 28.1), Arab countries currently possess 362 MVMs. This represents about 85% of the actual needs. This may look better than many other countries in Africa and Asia-Pacific (34% and 61%, respectively) [50]. Still, these facilities are not equally distributed among countries. High-income countries already have around 135% of their MVM needs, while UMIC and LMIC have 75.5% and 72.5% of their needs, respectively [27].

Optimal delivery of RT requires well-trained ROs, qualified MPs and RTTs, competent nurses, and non-medical staff. Unfortunately, some Arab countries are still lacking competency-based residency training programs. On the other hand, many Arab countries still have clinical oncology programs, with radiation oncology and medical oncology curricula over a minimal time. Lack of Work-Place Based Assessment and training on communication skills is another character of training programs in countries with high patient volume and a small number of supervising well-trained staff; Egypt is an example.

MPs working in the clinical environment are health professions per the International Labor Organization and WHO classification. However, they receive primarily theoretical education with very minimal clinical exposure during their undergraduate studies. Other challenges include a lack of incentives and opportunities for personal and professional development, unlike the opportunities offered to the doctors. Undergraduate Medical Physics Bachelor's Degrees are available in a limited number of universities in the Arab countries, for example, at King Abdulaziz University and Umm Al-Qura University, in Saudi Arabia. Otherwise, most MPs usually have a General Physics or Engineering undergraduate Bachelor's Degree then pursue their Master's Program in Medical Physics.

Postgraduate Medical Physics Certification is based chiefly on Master and Ph.D. studies. However, a limited number of Arab countries have established institution-based Medical Physics Clinical Residency Training, like King Hussein Cancer Center, Jordan, and King Faisal Specialist Hospital, Saudi Arabia. In addition, the Saudi Commission for Health Specialties established a National-wide Medical Physics Clinical Residency Training, awaiting to be launched.

Traditionally, highly qualified young staff from LMIC emigrate to HIC for training. Later, they choose to stay abroad with subsequent "brain drain" with more load on the already suffering health system [2]. There is an urgent need to fill the gaps in MVM availability, human resources, knowledge, and clinical experience in our region. However, the analysis of RT needs is focused more on the equipment and infrastructure with less attention to qualified professionals [51].

Needs assessment and gap analysis are essential for any improvement plan. This requires accurate registry and documentation systems. According to a recent publication, 17 of the 22 countries have population-based cancer registries [43]. However, data about radiotherapy facilities and human resources are lacking in many countries. Data derived from DIRAC is self-reported with no auditing or confirmation. In addition, this data does not consider the details of RT techniques [27].

28.4.2 Capacity Building

The IAEA has the longest track record for human capacity building in the field of radiation oncology in LMICs [2]. Training of an entire team, including ROs, MPs, RTTs, and occasionally nurses and maintenance engineers, has always been a part of any Technical Cooperation (TC) project to start a new RT facility [39]. Radiation oncology departments worldwide offered training opportunities to many LMIC trainees. The problem with these programs is the high cost and the eventual result of "brain drain." Most professional societies offer training courses and programs abroad, but the curricula of high-income countries are not applicable in home countries most of the time [16]. Some of the successful examples of training options include the American Society for Radiation Oncology's (ASTRO)/Association of Residents in Radiation Oncology's (ARRO)'s Global Health Scholar Program and the American College of Radiology Foundation's Goldberg-Reeder Resident Travel Grant [2]. There is a need for an adequate number of competency-based and well-structured radiation oncology programs in all Arab world countries to fill their national need. Some practical roadmaps can be followed in this regard, like the

"Specialty Portfolio in Radiation Oncology: A global certification roadmap for trainers and trainees" [31].

Telemedicine is an area that is gaining increasing attention. It can overcome many barriers of traditional training, such as time and distance barriers. It is challenging to provide care to cancer patients during the COVID-19 while protecting both patients and staff from infection. The use of video consultations and remote networking can save time, decrease physical contact and save resources.

Arab countries continue to collaborate with regional and international organizations for knowledge and skills transfer. With the new interest in career development in global health, there are many successful examples of twinning partnerships between regional institutes and international universities and organizations. An example from Morocco can be given here, in 1984, the first two Moroccan radiation oncology professors started a training program at the faculties of medicine of Rabat and Casablanca, which allowed the graduation of hundreds of Moroccan and African radiation oncologists. Since 2005, and thanks to the support of the Lalla Salma Foundation in partnership with the Ministry of Health, Morocco has made a giant technological leap by the acquisition of more than 40 linear accelerators equipped with the most advanced technologies to deliver high precision treatments.

28.5 Conclusion

Arab countries share language, culture, and history, but they have variable economic characteristics, with significant variation in radiotherapy services across different countries. There are many gaps in the current radiation oncology facilities. Many Arabic countries still lack systems of accurate and up-to-date data registries. Information about the status of RT in our region is mainly derived from sources like DIRAC. Training programs across many countries are sub-optimal. To face these challenges, Arab countries must collaborate both on the regional and international levels. Governments and international organizations need to invest in RT resources and help the less advantageous countries. Many successful and inspiring examples that other countries can follow are present.

28.5.1 Strengths and Limitations

This chapter describes many RT-related issues that can be used as a baseline for future studies. The authors tried to explore some dimensions of this field through the published literature and their expertise and networks. However, many Arab countries do not have well-established systems that document all aspects of cancer care, from infrastructure to workforce and outcomes. Data on RT infrastructure was derived from DIRAC, which is a self-reporting source with no verification. Also, data about cancer incidence was retrieved from GLOBOCAN estimates, which may not reflect the real-life registries. Information about other parts such as training programs, certification and licensing relied on personal communication between the authors and colleagues from different Arab countries, again with no external verification.

Conflict of Interest Authors have no conflict of interest to declare.

References

1. Abdel-Wahab M, Bourque J-M, Pynda Y, Iżewska J, Van der Merwe D, Zubizarreta E, Rosenblatt E. Status of radiotherapy resources in Africa: an International Atomic Energy Agency analysis. Lancet Oncol. 2013;14(4):e168–75. https://doi.org/10.1016/S1470-2045(12)70532-6.
2. Abdel-Wahab M, Nitzsche-Bell A, Olson A, Polo A, Shah MM, Zubizarreta E, Patel S. Radiation oncology in global health. In: Mollura DJ, Culp MP, Lungren MP, editors. Radiology in global health: strategies, implementation, and applications. Cham: Springer International Publishing; 2019. p. 349–60.
3. Alghamdi MA, et al. Scholarly activity of radiation oncologists in high-income developing countries: Saudi Arabia as an example. JCO Glob Oncol. 2021;7:378–83. https://doi.org/10.1200/GO.20.00449.
4. Arafa MA, Rabah DM, Farhat KH. Rising cancer rates in the Arab world: now is the time for action. East Mediterr Health J. 2020;26(6):638–40. https://doi.org/10.26719/emhj.20.073.
5. Atun R, Jaffray DA, Barton MB, Bray F, Baumann M, Vikram B, et al. Expanding global access to radiotherapy. Lancet Oncol. 2015;16(10):1153–86. https://doi.org/10.1016/s1470-2045(15)00222-3.
6. Baskar R, Lee KA, Yeo R, Yeoh K-W. Cancer and radiation therapy: current advances and future directions. Int J Med Sci. 2012;9(3):193–9. https://doi.org/10.7150/ijms.3635.
7. Blake M. I.4 advances in radiotherapy and radiotherapy innovations. J Thorac Oncol. 2019;14(11):S1157. https://doi.org/10.1016/j.jtho.2019.09.098.
8. CAMS. College of Applied Medical Sciences. 2021. Retrieved from https://cams.ksu.edu.sa/en/departments/radiological-sciences.
9. Connell PP, Hellman S. Advances in radiotherapy and implications for the next century: a historical perspective. Cancer Res. 2009;69(2):383–92. https://doi.org/10.1158/0008-5472.Can-07-6871.
10. Crookes W. Priority in the therapeutic use of X-rays, quoted by Grubbe, E.H. Radiology. 1933;21:156–62.
11. Datta NR, Samiei M, Bodis S. Radiation therapy infrastructure and human resources in low- and middle-income countries: present status and projections for 2020. Int J Radiat Oncol Biol Phys. 2014;89(3):448–57. https://doi.org/10.1016/j.ijrobp.2014.03.002.
12. Delaney G, Jacob S, Featherstone C, Barton M. The role of radiotherapy in cancer treatment: estimating optimal utilization from a review of evidence-based clinical guidelines. Cancer. 2005;104(6):1129–37. https://doi.org/10.1002/cncr.21324.
13. Elbanna S, Abdelzaher DM, Ramadan N. Management research in the Arab world: what is now and what is next? J Int Manag. 2020;26(2):100734. https://doi.org/10.1016/j.intman.2020.100734.
14. Frikha H, Chaouache K, Abdessaied S, Elhattab I, Bousselmi S, Ksouri W, et al. Implementation of a radiation therapy center in low and middle-income countries. the case of collaborative project to implement modern radiotherapy center in Tunisia. Int J Radiat Oncol Biol Phys. 2019;105(1):E445–6.
15. GLOBOCAN. Population fact sheets. 2020. Retrieved from https://gco.iarc.fr/today/fact-sheets-populations.

16. Gospodarowicz M. Global access to radiotherapy—work in progress. JCO Glob Oncol. 2021;7:144–5. https://doi.org/10.1200/go.20.00562.
17. Guidelines for the certification of clinically qualified medical physicists. Vienna: International Atomic Energy Agency; 2021.
18. Hamadeh RR, Borgan SM, Sibai AM. Cancer research in the Arab world: a review of publications from seven countries between 2000-2013. Sultan Qaboos Univ Med J. 2017;17(2):e147–54. https://doi.org/10.18295/squmj.2016.17.02.003.
19. Hellman S. Roentgen Centennial Lecture: discovering the past, inventing the future. Int J Radiat Oncol Biol Phys. 1996;35(1):15–20. https://doi.org/10.1016/s0360-3016(96)85006-1.
20. IAEA. DIRAC (DIrectory of RAdiotherapy Centres). 2021. Retrieved from https://dirac.iaea.org/Query/Countries.
21. IMPCB. International Medical Physics Certification Board. 2021. Retrieved from https://www.impcbdb.org/.
22. IOMP. The International Organisation for Medical Physics. 2021. Retrieved from https://www.iomp.org/.
23. Jackson SP, Bartek J. The DNA-damage response in human biology and disease. Nature. 2009;461(7267):1071–8. https://doi.org/10.1038/nature08467.
24. Khader J. Improving cancer outcomes through international collaboration in developing countries: King Hussein cancer center as a unique experience. J Glob Oncol. 2018;4(Supplement 2):161s. https://doi.org/10.1200/jgo.18.43300.
25. Khader J, Al-Mousa A, Al Khatib S, Wadi-Ramahi S. Successful development of a competency-based residency training program in radiation oncology: our 15-year experience from within a developing country. J Cancer Educ. 2020;35(5):1011–6. https://doi.org/10.1007/s13187-019-01557-8.
26. MEFOMP. Middle east federation of organizations of medical physics. 2021.
27. Mousa AG, Bishr MK, Mula-Hussain L, Zaghloul MS. Is economic status the main determinant of radiation therapy availability? The Arab world as an example of developing countries. Radiother Oncol. 2019;140:182–9. https://doi.org/10.1016/j.radonc.2019.06.026.
28. Mula-Hussain L. Undergraduate oncology education: mini-literature review with single institution experience from Iraq. In: Dubaybo B, editor. ACCESS Health Journal - Proceedings of the 7th international conference on health issues in Arab communities. Dearborn: The Arab Community Center for Economic and Social Services; 2015. p. 183–94.
29. Mula-Hussain L, Shamsaldin AN, Al-Ghazi M, Muhammad HA, Wadi-Ramahi S, Hanna RK, Alhasso A. Board-certified specialty training program in radiation oncology in a war-torn country: challenges, solutions and outcomes. Clin Transl Radiat Oncol. 2019;19:46–51. https://doi.org/10.1016/j.ctro.2019.08.002.
30. Mula-Hussain L, Wadi-Ramahi SJ, Zaghloul MS, Al-Ghazi M. Radiation oncology in the Arab world. In: Laher I, editor. Handbook of healthcare in the Arab world. Cham: Springer International Publishing; 2019. p. 1–19.
31. Mula-Hussain L, Wadi-Ramahi S, Li B, Ahmed S, de Moraes FY. Specialty portfolio in radiation oncology: a global certification roadmap for trainers and trainees (Handbook – Logbook). Qatar: Qatar University Press; 2021.
32. Murray LJ, Robinson MHJM. Radiotherapy: technical aspects. Medicine. 2016;44(1):10–4.
33. Niroomand-Rad A, Tabakov S, Duhaini I, Mahdavi R, Rasuli B, Naji N, et al. Status of medical physics education, training, and research programs in middle east. Med Phys Educ Train. 2017;5(2):16.
34. Pawlicki T, Hayman J, Ford E. Safety is no accident: a framework for quality radiation oncology and care. Arlington, VA: American Society for Radiation Oncology; 2019.
35. Planning National Radiotherapy Services: A Practical Tool. Vienna: International Atomic Energy Agency; 2011.
36. Porter A, Aref A, Chodounsky Z, Elzawawy A, Manatrakul N, Ngoma T, Orton C, Van't Hooft E. and Sikora K. A global strategy for radiotherapy: a WHO consultation. Clin Oncol. 1999;11(6):368–70.

37. Regaud C, Ferroux R. Discordance des effets de rayons X, d'une part dans le testicule, par le peau, d'autre parts dans le fractionment de la dose. Compt Rend Soc Biol. 1927;97:431–4.
38. Röntgen WG. Ueber eine neue Art von Strahlen. Sitzungsberichte der physikalisch-medicinischen Gesellschaftzu Wurzburg. Sitzung. 1895;30:132–41.
39. Rosenblatt E, Acuña O, Abdel-Wahab M. The challenge of global radiation therapy: an IAEA perspective. Int J Radiat Oncol Biol Phys. 2015;91(4):687–9. https://doi.org/10.1016/j.ijrobp.2014.12.008.
40. Rosenblatt E, Fidarova E, Zubizarreta E, Barton MB, MacKillop W, Jones GW, et al. Radiation therapy utilization in middle-income countries. Int J Radiat Oncol Biol Phys. 2016;96(2, Supplement):S37. https://doi.org/10.1016/j.ijrobp.2016.06.102.
41. SCHS. Saudi Commission for Health Specialties. 2021. Retrieved from https://www.scfhs.org.sa/Pages/default.aspx.
42. Setting Up a Radiotherapy Programme. Vienna: International Atomic Energy Agency; 2008.
43. Siddiqui AA, Amin J, Alshammary F, Afroze E, Shaikh S, Rathore HA, Khan R. Burden of cancer in the Arab world. In: Laher I, editor. Handbook of healthcare in the Arab world. Cham: Springer International Publishing; 2020. p. 1–26.
44. Silbermann M, Pitsillides B, Al-Alfi N, Omran S, Al-Jabri K, Elshamy K, et al. Multidisciplinary care team for cancer patients and its implementation in several Middle Eastern countries. Ann Oncol. 2013;24(Suppl 7):vii41–7. https://doi.org/10.1093/annonc/mdt265.
45. Slotman BJ, Cottier B, Bentzen SM, Heeren G, Lievens Y, van den Bogaert W. Overview of national guidelines for infrastructure and staffing of radiotherapy. ESTRO-QUARTS: work package 1. Radiother Oncol. 2005;75(3):349–54. https://doi.org/10.1016/j.radonc.2004.12.005.
46. WHO. World Health Organization. Cancer control: a global snapshot in 2015. 2015.Retrieved from https://www.who.int/cancer/Cancer_Control_Snapshot_in_2015.pdf.
47. World Health Organization. Global health estimates 2020: deaths by cause, age, sex, by country and by region, 2000–2019. Geneva: WHO; 2020.
48. Zaghloul MS. Radiation oncology facilities in Africa: what is the most important: equipment, staffing, or guidelines? Int J Radiat Oncol Biol Phys. 2008;71(5):1600–1.; author reply 1601. https://doi.org/10.1016/j.ijrobp.2008.03.053.
49. Zaghloul MS, Bishr MK. Radiation oncology in Egypt: a model for Africa. Int J Radiat Oncol Biol Phys. 2018;100(3):539–44. https://doi.org/10.1016/j.ijrobp.2017.10.047.
50. Zubizarreta E, Van Dyk J, Lievens Y. Analysis of global radiotherapy needs and costs by geographic region and income level. Clin Oncol (R Coll Radiol). 2017;29(2):84–92. https://doi.org/10.1016/j.clon.2016.11.011.
51. Zubizarreta EH, Fidarova E, Healy B, Rosenblatt E. Need for radiotherapy in low and middle income countries – the silent crisis continues. Clin Oncol. 2015;27(2):107–14. https://doi.org/10.1016/j.clon.2014.10.006.

Zeinab Elsayed is a medical graduate of Ain Shams University (ASU) in Cairo, where she also obtained both M.Sc. & Ph.D. in Clinical Oncology. Dr. Elsayed got a second M.Sc. in Advanced Oncology from Ulm University (Germany) and became a FAIMER Fellow (Foundation for Advancement of International Medical Education and Research). Dr. Elsayed is an Oncology Professor & the Director of the Extended Modular Program for UG at ASU. She is an active member of EORTC-QOL and HN Groups, an author of Cochrane Hepatobiliary and Thoracic Groups, a member of Guidelines International Network (G-I-N) (LMIC-WG) & has published in national and international medical journals.

Issam Lalya was born in 1983 in Casablanca, Morocco is a military doctor, specialist in radiation oncology since 2012, and associate professor at Cadi Ayyad University in Marrakech since 2016 and Mohammed-V University in Rabat since 2021. He authored and co-authored numerous publications in highly indexed journals, including three in the New England Journal of Medicine (NEJM). He is mainly involved in the implementation and teaching of innovative radiation therapy techniques (Intensity Modulated Radiation Therapy, Stereotactic Radiotherapy) and postdoctoral education in many fields of oncology.

Hussain AlHussain graduated from King Saud University in 2004, then did his Radiation Oncology Residency (2007–2011) and Sub-Specialty Fellowship in Head, Neck, Neuro-Oncology and Stereotactic Radiosurgery (2012–2013), both at the University of Ottawa, Canada. He has been a Fellow of the Royal College of Physicians of Canada since 2011 and received his Master of Healthcare Management from McGill University and CPHQ Certification in Healthcare Quality. Dr. AlHussain is a consultant Radiation Oncologist at the King Fahad Medical City (2013–Present), and he is the Executive Director of Accreditation, Saudi Commission for Health Specialties (2018–Present).

Layth Mula-Hussain was born, raised, and gained his medical degree in Mosul, Iraq. He did radiation oncology specialization and further training and education in Jordan, Germany, and Canada. Currently, he is an ESTRO Fellow & a consultant physician at the Sultan Qaboos Comprehensive Cancer Care and Research Center in Muscat, Oman. Layth was the Founding Director of the first radiation oncology board program in Iraq (2013–2017). He acted as an Expert within imPACT IAEA (2013 & 2021) and was an ASCO International Affairs Steering Committee member (2016–2019). He authored/co-authored five books, six chapters, 50+ manuscripts and did 100+ scientific presentations.