RESEARCH COMMUNICATION

Radiation Oncology Facilities in Turkey: Current Status and Future Perspectives

Fatih Goksel[1,3*], Orhan Koc[1,4], Nejat Ozgul[2], Murat Gultekin[2], Melike Abacioglu[2], Murat Tuncer[2], İrfan Sencan[1,3]

Abstract

Background and purpose: An analysis of the current radiotherapy status in Turkey was conducted to establish a comprehensive baseline. Turkey's future demand analysis in view of international benchmarks was conducted. Moreover, the ministerial plans are shared to present an example for making a comprehensive planning in developing countries. Methods: The data from all radiotherapy centers in Turkey was collected through a survey and cross-checked with primary research and government data. Survey covered the status of radiotherapy centers in terms of major equipment and personnel. Data regarding manpower currently working is obtained from relevant academic centers and occupational associations. Results: The latest ministerial registry data demonstrated 150,000 new cancer cases each year with 400,000 patients living with cancer in Turkey. Around 100,000 patients are estimated to need radiotherapy each year - a figure expected to reach around 170,000 by 2023. The current numbers for radiotherapy centers, megavoltage equipment, radiation oncologists, medical physicists and radiotherapy technicians are 90, 186, 446, 130 and 600 respectively. By 2023, Turkey will need around 680 radiation oncologists, 624 medical physicists, 2,650 radiotherapy technicians and 379 megavoltage machines. Conclusion: Turkey faces a slight oversupply of radiation oncologists in contrast to undersupply in megavoltage machines and other personnel. Careful planning is required to allocate limited resources. The purchase of the equipment and employment policies should be structured as part of national cancer control program.

Keywords: Turkey - cancer radiotherapy - equipment - staff - future politics

Asian Pacific J Cancer Prev, **12**, 2157-2162

Introduction

Turkey, a bridge over Asia and Europe, holds characteristics of both developed and developing countries in terms of the cancer types and their incidences observed. The types of cancers are similar to those observed in developed countries whereas the incidence corresponds to nearly 1/3 of developed countries (Kanser.gov, 2004-2006; Tuncer et al., 2010; TURKSTAT, 2011). This difference in incidence is mainly due to the young population of Turkey where the population above 45 is only 26% of total population (Karakaya, 2009). The population is approximately 74 million with annual cancer incidence of 245/100,000 in males and 164/100,000 in females (Tuncer et al., 2010). Accordingly, 150,000 new cases of cancer are diagnosed each year and there are 400,000 patients living with cancer today.

Given 52%-60% of patients need radiotherapy and 25% need an additional round, around 100,000 to 111,000 patients are estimated to need radiotherapy for the treatment of cancer per year (Intersociety-council for Radiation Oncology, 1991; Victorian State Government Department of Human Services, 1998; DeVita Jr et al., 2001; 5- Victorian Radiotherapy Service, 2008; Barton et al., 2006). The size of population above 45 is estimated to be 34 % of whole population in 2023 (Karakaya, 2009; TURKSTAT, 2011). Given the cancer is generally a mid-old age condition and the 90% of newly diagnosed are above 45 years old, the number of patients who will require radiotherapy is expected to reach 170,000 to 185,000 patients by 2023.

Radiotherapy is one of the most important treatment modalities in cancer. However, radiotherapy facilities need continuous upgrades and regular technical care making their sustenance expensive. Therefore, it is essential for each country to define its baseline situation and make future plans according to its burden of disease in order to have a successful cancer control program. Defining future demand for manpower and devices for radiotherapy is integral to these future strategic plans.

Turkey, with the aid of World Health Organization (WHO) has launched a cancer control program for 2009-2015 with five main pillars: registry, prevention, screening-early diagnosis, treatment and palliative care (10). The strategic ministerial plan on treatment section includes not only the medical or surgical facilities, but

*[1]General Secretariat of Curative Services, [2]Department of Cancer Control, Turkish Ministry of Health, [3]Diskapi Yildirim Beyazit Training & Research Hospital, [4]Yenimahalle Public Hospital, Ankara, Turkey *For correspondence: fatihgoksel@gmail.com*

also the radiotherapy facilities. This article summarizes the current level of radiotherapy facilities and manpower in Turkey and is unique for it is the first needs assessment and first comprehensive data set for Turkey regarding radiotherapy. This article is also the first analysis for Turkey that aims to align closer with international benchmarks. The authors hereby aims to provide an example for radiotherapy planning in developing countries where limited resources demands careful planning.

Materials and Methods

Baseline status survey

A survey was prepared by the Ministry of Health (MoH) and sent to all radiotherapy centers in Turkey through each city's medical authority. The survey included questions regarding the type (external radiotherapy/ brachytherapy /simulator and treatment planning devices), model and age of radiotherapy devices in addition to the name of the radiotherapy center, the type of the center (Ministerial/ University/ Private) as well as the personnel. In order to evaluate the manpower status, all centers were asked to report the number of radiation oncologists, medical physicists and radiotherapy technicians in the survey. Information on potential personnel currently on training and institutions providing such education was supplied by the Turkish Council of Higher Education.

Survey was sent in October 2010 and collected from all centers by April 2011. A response rate of 100% was achieved. The survey results were cross-checked and complemented by the data from Turkish Atomic Agency and Ministry of Health Curative Services Department, to which all centers are required to apply for licensing and upgrading every 1-2 years. In addition to such verification, data was confirmed through authors' primary research. Full data set was consolidated by the Ministry of Health. Ministry of Health within the scope of this study has classified the radiotherapy centers into three levels. Level 1 was defined as Private Center Radiotherapy Laboratories or Clinics with 1 linear accelerator, 1 simulator, 1 radiation oncologist, 1 medical physicist. All Level 1 centers are private centers. Level 2 was defined as Oncology Diagnosis and Treatment Center with minimum 1 linear accelerator, 3D planning system, 1 simulator, 2 radiation oncologists, 2 medical physicists, 2 technicians per each equipment and bed utilization. Level 3 was defined as Comprehensive Oncology Center with at least 2 linear accelerators, brachytherapy equipment, 3D planning system, 1 simulator, 1 PET-CT 3 radiation oncologists, 3 medical physicists, 2 technicians per each treatment unit, 2 medical oncologists and reserved bed utilization for cancer patients.

Demand Analysis & Ministerial Plans

Manpower and equipment need for radiotherapy facilities were determined based on the number of newly diagnosed patients. Given 2-2.2 per 100,000 incidence, the number of newly diagnosed cancer patients per year is estimated to be 145,000-160,000 (Tuncer et al., 2009; 2010). Around 52% to 60% of cancer patients are assumed to take radiotherapy at least once and an additional 25% might receive a second course. Therefore, the number of patients who require radiotherapy was estimated to be around 100,000-110,000 patients every year.

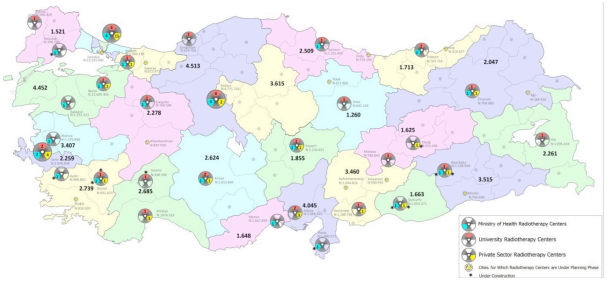

Figure 1. Distribution of Radiotherapy Centers in Turkey *Numbers indicated on each region refers to million population in the region

During planning, given different socioeconomic factors, population size, and travel related behavior of patients, the country was divided into 29 medical regions by the MoH - as shown in Figure 1. With this division approximately 4-5 cities were linked to each oncology center. Manpower and equipment planning was done in view of these population segments.

Orthovoltage machines were excluded from study as they are no longer in use in Turkey. Regarding megavoltage unit load, International Atomic Energy Agency (IAEA) (2010) suggests 200-500 patients per machine depending on treatment complexity. European service planning guidelines suggest 450 patients per machine (Slotman et al., 2005). Other countries experienced in such planning such as Australia targets 400 patients per machine (Victorian Department of Human Services, 2009). Within this study, Turkey plans to target 400 patients per machine in large cities such as Istanbul, Ankara and İzmir and the other medical center cities. For smaller cities which are among the centers for 29 medical regions, depending on the ease of travel to these cities Turkey plans 400-500 patients per machine. For those cities which are not centers of the medical regions but have higher than 500,000 population and are easy to travel to, 500 patients per machine have been planned. These calculations assume 8.5-9 daily active hours, 220 annual working days, 4.1-5 patients receiving radiotherapy per hour and 18.5 fractions per patient.

According to various international benchmarks, one radiation oncologist per 250 newly diagnosed, one medical physicist per 400 newly diagnosed patients, two radiotherapy technicians per megavoltage unit up to 25 patients treated daily or four radiotherapy technicians per megavoltage unit up to 50 patients treated daily (also two for every 500 patients simulated annually, one mould room technician per 600 patients treated annually and one supervisor per center) are suggested (Belletti et al., 1996; Kahn, 2003; Round et al., 2010). For radiotherapy manpower planning in Turkey these benchmarks have been used.

In order to estimate the future demand for radiotherapy machines, population projections by Mehmet Dogu Karakaya have been used (2009). For current population statistics, those published by Turkish Statistical Institute (TUIK) are used (TURKSTAT, 2010). Given increase in population to 82,293,000 and increased incidence of

Table 1. Distribution of Radiotherapy Machines, Equipment and Staff per Type of Owner Institute

	Radiation Oncology Centres	Radiation Oncologists	Co-60	LİNAC	Total	Brachy-therapy	Cyber-knife	Gamma-knife
Public hospitals	21+8*	244	10	41	51	5	3	0
University hospitals	31	140	20	57	77	16	2	3
Private hospitals and centers	38	62	10	48	58	14	2	1
Total	90+8	446	40	146	186	35	7	3

* Radiotherapy centers are under construction

cancer at 3-3.2 per 1000 predominantly due to aging population the expected newly diagnosed patients per year is 245,000-265,000. Future ideal supply was then calculated based on the international benchmarks and the planning principles presented above. The supply demand gap of Turkey in radiotherapy is also compared to those of other countries determined in studies previously conducted in Europe, Asia Pacific as well as all countries with data on international databases.

Results

Radiotherapy Facilities

Facilities: There are currently 90 radiotherapy centers in Turkey and additional 8 centers are under construction. This indicates one center per 1.35 million population. The distribution of the radiotherapy devices according to the type of the centers is shown in Table 1. Sixty-seven percent of linear accelerators are owned by the state and university hospitals. Around 20% of centers are level 3, 60% are level 2 and 20% are level 1. Forty-two percent of all centers are private ones, whereas 23% is state owned and 34% are university hospitals. Private centers are equally distributed between level 1 and 2 centers. By 2023, 14 level 3 centers and 34 level 2 centers belonging to the Ministry, and 18 level 3 and 27 level 2 centers belonging to the university hospitals are planned. All level 1 centers are aimed to be converted to level 2 centers.

It is also observed that in western, southern and middle regions of Turkey have less than 770,000 population per center whereas this number is close to 1 million in the north and 1.5 m illion in the southern eastern regions of Turkey. However, it should be noted that in the east as there are fewer private investments, each state and university radiotherapy center has higher number of linear accelerators per center than the ratio found in the western parts of Turkey.

Equipment: Currently, there are 40 Cobalt-60 (Co-60) units and 146 linear accelators in Turkey. This indicates 1.8 linear accelators per 1 million population. The breakdown of the number of machines per type and owner institute can be seen in Table 1. Thirty percent of these megavoltage machines have been in use for more than 10 years and operates on outdated technology. There are 35 brachytherapy units and 131 simulators (55 conventional, 66 computed tomography (CT), 10 positron emission tomography computed tomography (PET-CT)). Each center is also equipped with at least one treatment planning system (TPS).

Given international benchmarks and Turkey's current plan the ideal supply is 222 for 2011 and 379 for 2023. There are wide regional gaps: almost 40% of all linear accelarators (not including Cobalt 60 units) are installed in Istanbul and Ankara

Table 2. Manpower in Radiation Oncology, Turkey 2011

	Current number	Est[1] required	Gap[2]	Est[1] capacity
Radiation oncologist	446	420-440	-6	680
Medical physicist	170*	357-450	187-280	624-780
Radiotherapy technician	600	1400-1600	600-800	2650

Est, estimated; [1]per international benchmarks; [2]supply-demand

Personnel status

Radiation oncologists: The number of radiation oncologists has risen from 85 in 1985 to 446 by 2011. Currently out of 446 radition oncologists, 244 work for public hospitals, 140 work for the university hospitals and around 62 work for the private institutions. Between April 2006 and 2011, 156 radiation oncologists have been assigned as radiation oncologists under the public mandatory service. There are 2.97 radiation oncologists per 1000 newly diagnosed cancer patients.

The estimated ideal supply for 2011 is between 420 and 440. On average 30 new radiation oncologists are assigned per year. Given this trend, the ideal target of 680 radiation oncologists according to the international benchmarks can be easily reached by 2023. Table 2 shows the current supply, gap and supply required in 2023.

Medical physicists: Other than the 130 medical physicists with master degree in Radiation Oncology, additional 56 physicists/ physics engineers without master's degree are working in this field. It is predicted that 40 medical physics students will graduate this year to give a total of 170 medical radiation physicists with master's degree by the end of 2011. It is also expected that 58 students will graduate in 2012. There are now 11 academic centers providing the master's degree program compared to 9 centers in 2010. Currently there are 0.98 medical physicists per 1000 newly diagnosed cancer patients. Ideal supply per international benchmarks for 2011 is 357-450 and for 2023 is 624-780.

Radiotherapy technicians: Currently, there are 600 radiotherapy technicians. This indicates 4 radiotherapy technicians per 1000 newly diagnosed cancer patients. Five undergraduate degree programs offered in Turkey have 110 new graduates every year. Given current supply of linear accelerators the ideal supply for 2011 is 1400.

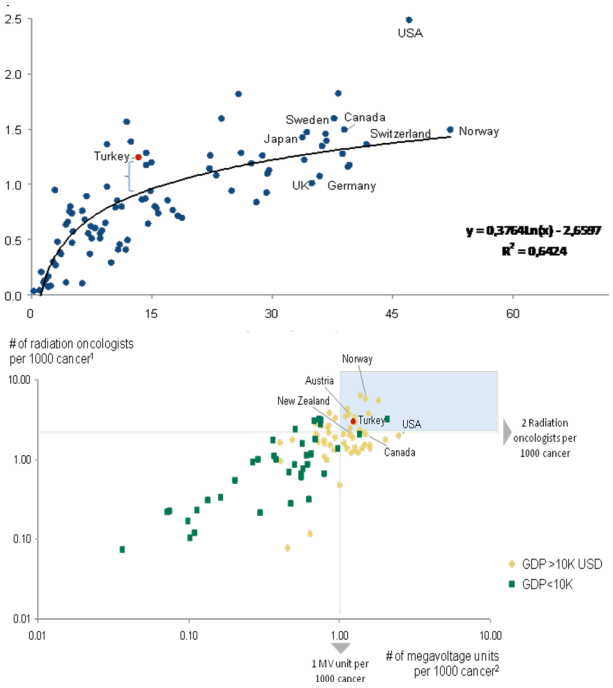

Figure 2. International Comparisons. a) Radiotherapy supply in terms of megavoltage units (including cobalt 60 & linear accelerators per 1000 crude all cancers excluding non-melanoma skin cancer) with respect to wealth. 2010 projections for crude number of cancers newly diagnosed, 2010 GDP PPP per capita projections and latest IAEA data used. Turkey cancer incidence data from Turkish Ministry of Health Department of Cancer Control, Turkey megavoltage unit data obtained in this study have been used. b) Radiotherapy supply in terms of radiation oncologists with respect to megavoltage units.[1]Data presented on log scale 2. Megavoltage units including cobalt 60 & linear accelerators per 1000 crude all cancers excluding non-melonoma skin cancer presented on log scale

Given ideal number of linear accelerators, the ideal supply for 2011 is 1600 and for 2023 it is 2650 technicians. This indicates that there is a large gap still to be fulfilled.

Gross national income per capita

When the current level of supply in Turkey is compared with supply level in other countries, for which Globocan cancer incidence data and IAEA megavoltage machines and manpower data are available, it is found to be above the expected trendline (Globocan, 2008; IMF World Economic Outlook Database, 2010; IAEA Directory of Radiotherapy Centers, 2011). According to International Monetary Fund (IMF) World Economic Outlook database, Turkey's gross domestic product per capita at purchasing power parity (GDP per capita PPP) is only at 13,392 USD. Compared to its GDP, Turkey's efforts on radiotherapy parallel that of the developed countries and surpasses its contemporaries in the similar wealth level. Figure 2a and 2b depict this observation. Turkey is among the few countries which have more than two radiation oncologists and one megavoltage machine per 1,000 cancer patients.

Discussion

There are multiple ways to calculate radiotherapy equipment and manpower need. Ratio of linear accelerators and staff per million population is commonly used. However, there are differences in age profiles and cancer incidence rates between developing and developed countries. Therefore, a common method suggested by IAEA is to use crude number of new cases per year, which is used in this study. A more scrutinous comparison with international benchmarks can be initiated in future studies in terms of the distribution of the types of cancer diagnosed and the stage at which it is diagnosed as more information becomes available. The rates used in this study are closely aligned to high resourced countries' guidelines accepted as general guidelines by the European Society for Therapeutic Radiology and Oncology (Slotman et al., 2005).

Based on the survey, there is an undersupply of radiotherapy equipment. The estimated ideal number of linear accelerators is 222 and the current number is 186. Current supply is 84% of the ideal supply. A comparison of the current capacity to the estimated required capacity shows that among 25 European countries only Sweeden, France, Belgium and Slovakia are above 85% of their ideal supply (Bentzen et al., 2005). Hence the supply gap in Turkey appears as comparable to other European countries. Furthermore, Figures 2a & 2b indicate that Turkey's supply level is above its counterparts within the similar GDP per capita range. However, given 30% of current linear accelators in Turkey have been in use more than 10 years and operates on outdated technology the true supply gap is higher. Therefore, it is crucial to plan for upgrading and renewal in the national planning.

Turkey's current level of megavoltage units per 1000 cancer patients is at 1.24. When compared with countries in Asia Pacific region in Tatzusaki et. al.'s study, out of 17 countries, only Japan, Australia, New Zealand and Singapore surpasses this ratio. Regarding manpower, 2.92 radiation oncologists per 1000 cancer patient is only observed in Singapore and Mongolia, whereas in Japan this number is 1.4 and in Australia it is 1.98 (22). Other studies reported by IAEA indicates that megavoltage units per 500 cancer patients receiving radiotherapy is 0.92 in Western Europe, 1.14 in North America, 1.33 in Japan & Australia, 0.65 in Latin America & Caribbean and 0.78 in Middle East in comparison with 0.87 in Turkey (Tatsuzaki and Levin, 2001). This again indicates that supply in Turkey is comparable to levels provided in highly resourced countries.

However, to understand the true level of accessibility of radiotherapy, a further study is required. In Turkey the state covers full cost of cancer treatment in state and university hospitals. Even though some private institutions have reimbursement agreements with the state, given that 30% of the linear accelators are owned by the private sector, true accesibility rates should be further analyzed. Moreover, waiting periods should be analyzed as a performance indicator and compared to international benchmarks. Even countries such as Japan and Australia which highly rank across benchmarks are noted to suffer from inequal distribution of services within country (International Atomic Energy Agency, 2011).

Given the numbers, Turkey faces a slight oversupply in the number of radiation oncologists in contrast to the undersupply of megavoltage equipment and the other

personnel. Turkish Ministry of Health Department of Medical Education has recently engineered a plan to adjust the number of residents in training program with the equipment requirements. It has been decided that in order to ensure high quality training, the residents should be assigned to only those centers with minimum two LINACs and latest technology. Similarly, those specialists who lack experience with latest technology (image guided radiation therapy (IGRT), intensity modulated radiation therapy (IMRT), stereotactic radiation surgery(SRS) etc.) should be enrolled in educational programs. The Ministry has identified those centers without high technology, started to equip them with necessary radiotherapy units and provide those specialists' education in centers excelling in the use of latest technology.

By the year 2011, there is still a supply-demand gap of 187-280 medical radiation physicists. Previously the definition of the medical radiation physicist's task was not well defined. With recent studies, this definition has been revised to form three categories: medical radiation physicist, nuclear medicine physicist, radio-diagnostic physicist. The full task descriptions are yet to be completed in line with the European Atomic Energy Community (EURATOM) 97/43 directives and IAEA criteria (The European Atomic Energy Community, 1997). The Turkish Council of Higher Education is working on increasing number and capacity of related degree programs and alignment with European Federation of Organizations for Medical Physics (EFOMP) educational recommendations (Eudaldo and Olsen, 2010). In addition, to solve the problem of limited number of the medical radiation physicists, the working hours has been expanded from 5 hours to 7 hours per day and 56 engineers of Physics without master degree were put on a training program to support medical radiation physicists.

Today, a complex technology is used and as healthy tissues are better protected higher doses are delivered in treatment. This also means that in addition to planning, implementation should also be carefully done. In Turkey, there is a supply-demand gap of 600-800 radiotherapy technicians. In some cases, instead of 2, 1 radiotherapy technician may assist per machine up to 25 patients per day. This practice would decrease the gap to around 400. However, in this planning Turkey tries to strive for higher quality and efficiency therefore assigns 2 technicians up to 25 patients treated daily followed by 2 other technicians for another set of 25 patients per day. The gap Turkey faces is tried to be curbed by providing the necessary education in radiotherapy to radiology technicians. The number of hours of service has been increased from 5 hours to 7 hours per day. The capacity increase at universities as planned by Council of Higher Education should be continued in line with the central radiation oncology planning. For near future, there is one additional undergraduate program to be opened.

There are wide regional gaps in the supply of radiotherapy equipment: Around 40% of all linear accelators are found to be installed in Istanbul and Ankara. According to authors' primary research, this is believed to be due to cancer patients' health care behavior in Turkey, where the patient seeks multiple consultations and multiple therapy methods in larger cities.

Given competing needs among different regions, a phased plan is put into practice. First the radiation oncology centers were classified into three categories based on their urgency of need: Those with highest need is planned to be equipped during 2010-2011. These centers are those that do not have any megavoltage unit and are located in a city of medical region center. The equipment for these centers are currently being installed. Those centers with second highest need are planned to be equipped during 2011-2015. Two types of centers exist in this category. First type is found in a city of medical region center and has over-utilized machines and relatively longer waiting lists. Second type is a center which is not in a medical region center but service to over 500,000 population and does not have linear accelerators. The remaining centers' need is in the long term and should be planned for renewals between 2011- 2023. All centers with out of date equipment should be planned for updates and replacements. The roll out policy should follow a phased approach where first linear accelator is installed and the second linear accelator is installed only given the full capacity usage of the first installed one.

In conclusion, as common for all developing countries, Turkey faces difficulties in the expensive transfer of latest technology and updates required in radiation therapy. The lack of local production makes Turkey dependent on import of such devices. Accordingly, such expensive investments need a situation analysis and proper planning as outlined in this article. This article compares the current supply with international benchmarks and projects the expected demand for 2023. For succesful cancer control planning, treatment phase, particularly radiotherapy center plans should be planned at least one decade before the actions are taken. The authors hope that all developing countries develop such a plan before committing their national financial resources.

Acknowledgements

The authors would like to thank Prof. Dr. Ferah Yıldız for her invaluable contributions regarding academic review of the article. Dr. Ferah is a faculty of Hacettepe University Radiation Oncology Department.

References

Barton MB, Frommer M, Shafiq J (2006). Role of radiotherapy in cancer control in low-income and middle-income countries. *Lancet Oncol*, **7**, 584-95.

Belletti S, Dutreix A, Garavaglia G, et al (1996). Quality assurance in radiotherapy: the importance of medical physics staffing levels. Recommendations from an ESTRO/EFOMP joint task group. *Radiother Oncol*, **41**, 89-94

Bentzen SM, Heeren G, Cottier B, et al (2005). Towards evidence-based guidelines for radiotherapy infrastructure and staffing needs in Europe: the ESTRO QUARTS Project. *Radiother Oncol*, **75**, 355-65.

DeVita Jr V, Hellman S, Rosenberg SA (2001). Cancer: Principles and Practices of Oncology. 7th ed. Philadelphia: J. B.Lippincott.

Eudaldo T, Olsen K (2010). The European Federation of Organisations for Medical Physics. Policy Statement No. 12: The present status of Medical Physics Education and Training in Europe. New perspectives and EFOMP recommendations. *Phys Med*, **26**, 1-5.

Globocan (2008) Database. 2010 projections. 2010. [cited 2011 July 1]. Available from: http://globocan.iarc.fr/

IAEA Directory of Radiotherapy Centers (DIRAC) Database. na. [cited 2011 July 1]. Available from: http://nucleus.iaea.org/HHW/DBStatistics/DIRAC/index.html

International Atomic Energy Agency (2010). Planning National Radiotherapy Services: A Practical Tool [Internet]. Vienna: [cited 2011 June 7]. Available from:http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1462_web.pdf

International Atomic Energy Agency (2011) Inequity in Cancer Care: A Global Perspective [Internet]. Vienna: [cited 2011 June 7]. Available from: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1471_web.pdf

IMF World Economic Outlook Database (2010). [cited 2011 July 1]. Available from: http://www.imf.org/external/pubs/ft/weo/2010/02/weodata/index.aspx

Intersociety-council for Radiation Oncology (1991). Radiation Oncology in Integrated Cancer Management, Report to the Director of the National Cancer Institute. [Internet] Washington DC: [cited 2011 Jan 30]. Available from: http://www.aapm.org/pubs/reports/BLUEBOOK.pdf

Kahn FM. The Physics Radiation Therapy. 3rd ed. Lippincott Williams & Wilkins. 2003.

Kanser.gov (2011). 2004-2006 Turkey Cancer Incidence in years 2004-2006]. Ankara: Turkish Ministry of Health, Department of Cancer Control; na [updated na; cited 2011 Jun 5]. Available from: http://www.kanser.gov.tr/folders/file/8iL-2006-SON.pdf

Karakaya MD. Provincial and regional population projections for the centenary of the Republic of Turkey [dissertation]. [Ankara]: Hacettepe University; 2009. 416 p.

Round WH,Tay YK, Ng KH, et al (2010). AFOMP Policy Statement No 2. Recommended clinical radiation oncology medical physicist staffing levels in AFOMP countries. *Australas Phys Eng Sci Med*, **33**, 7-10.

Slotman BJ, Leer JWH (2003). Infrastructure in the Netherlands: Evaluation of prognoses and introduction of a new model for determining the needs. *Radiother Oncol*, **65**, 345-9.

Slotman BJ, Cottier B, Bentzen SM, et al (2005). Overview of national guidelines for infrastructure and staffing of radiotherapy. ESTRO-QUARTS: Work package 1. *Radiother Oncol*, **75**, 349-54

Tatsuzaki H, Levin CV (2001). Quantitative status of resources for radiation therapy in Asia and Pacific region. *Radiother Oncol*, **60**, 81-9.

The European Atomic Energy Community (1997) Council Directive EURATOM 97/43 [Internet]. na: European Commission on Energy, [cited 2011 June 7]. Available from: http://www.ec.europa.eu/energy/nuclear/radioprotection/doc/legislation/9743_en.pdf

Tuncer MA, Ozgul N, Olcayto E, Gultekin M. Erdin B (2009). National Cancer Control Programme. 1st ed. Ankara: Republic of Turkey Ministry of Health; 110 p.

Tuncer MA, Ozgul N, Olcayto E, Gultekin M (2010). Cancer Control in Turkey. 1st ed. Ankara: Republic of Turkey Ministry of Health; . 412 p.

TURKSTAT [Internet]. Mid-year population projections by age group and sex. Ankara: Turkish Statistical Institute. na – [cited 2011 Jan 1]. Available from: http://www.turkstat.gov.tr/VeriBilgi.do?tb_id=39&ust_id=11

Victorian Department of Human Services (2009) Establishing Radiation Oncology Services in Regional Areas [Internet]. Melbourne: Department of Health and Ageing [cited 2011 June 15]. Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/7C9EDBEFAF2DBB8CCA25765F000F0CEC/$File/Establishing%20Radiation%20Oncology%20Services%20in%20Regional%20Areas.pdf

Victorian Government Department of Human Services (2008) Victorian Radiotherapy Service Plan 2006-2011 [Internet]. Melbourne: Metropolitan Health & Aged Care Services [cited 2011 Jan 30]. Available from:http://www.health.vic.gov.au/radiotherapy/radiotherapy-service-plan06-11.pdf

Victorian State Government Department of Human Services (1998). Review of Radiotherapy Services. [Internet]. Melbourne: Acute Health Division [cited 2011 Jan 30]. Available from:http://www.dhs.vic.gov.au/ahs/archive/radiotherapy/radiorev.pdf