Review of Current Status of Radiotherapy Facilities and Assessment of Required Time for Radiotherapy Delivery Workflow in Turkey: On Behalf of Turkish Society for Radiation Oncology

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ABSTRACT

The aim this study is to evaluate current status and workload of radiotherapy (RT) centers in Turkey, by assessing time and staff required during core treatment procedures in patients with different tumor sites. A survey sent via e-mail to all hospitals that are actively treating patients with RT, that aimed expose the details on type of the techniques being used and the time spent for treatment planning and delivery for the different techniques according to different tumor sites. The results were evaluated by several variables, the type of the center (university hospitals or state-run hospitals) and the number of patients treated per year per center (<1000 patients/year treated vs. ≥1000 patients/year treated). The survey was sent to 48 centers and the return rate was 71% (34 centers). Average daily treatment course performed by one physician was 192 per year (range: 41 - 650). Median number of patients treated by a specialist per year was 210 (range: 79 - 650) in the university hospitals and 101 (range: 41 - 167) in the state-run hospitals. Median time spent for treating a patient with 3-dimensional conformal RT (3DCRT) was 4 h, and it was 5 h 45 min for intensity-modulated RT (IMRT). The time spent for all cancer types treated with 3DCRT and IMRT was higher in state-run hospitals compared to university hospitals. With increasing use of newer RT techniques, the time spent for treating patients increases. Besides adequate equipment, sufficient and well-trained staff is required to achieve these newer RT technique benefits for the patients.

Keywords: Human resources, Radiotherapy facilities, Staffing, Time required

ÖZET

Türkiye'deki Radyoterapi Donanımının Mevcut Durumu ve Radyoterapi Uygulaması için Gereken Sürenin İncelenmesi: Türk Radyasyon Onkolojisi Derneği Çalışması

Bu çalışmanın amacı, Türkiye'deki radyoterapi (RT) merkezlerinin güncel durumu ve iş yükü değerlendirmesi, farklı tümörlü hastaların tedavi sırasında ekibin harcadığı süreler analiz ederek değerlendirmektir. Farklı tümörlerin tedavisi sırasında kullanılan teknikleri ve farklı teknikler için tedavi planlaması ve uygulam sırasında harcanan zamanı değerlendirmek amacı ile, aktif olarak RT uygulaması yapan tüm hastanelere e-mail yolu ile anket yollanmıştır. Sonuçlar, merkez türü (üniversite hastanesi veya devlet hastanesi) ve yıllık tedavi edilen hasta sayısına (yıllık tedavi edilen hasta sayısı <1000 veya yıllık tedavi edilen hasta sayısı ≥1000) göre değerlendirilmiştir. Anket 48 merkeze gönderilmiş olup ankete yanıt oranı %71 (34 merkez) olarak bulunmuştur. Bir hekimin yıllık tedavi seansı 192 (aralık 41-650) olarak bulunmuştur. Hekimin yıllık tedavi edilen ortalama hasta sayısı üniversite hastanesinde 210 (aralık: 79-650) ve devlet hastanesinde ise 101 (aralık: 41-167) olarak bulunmuştur. Bir hastayı 3-boyutlu konformal RT (3BKRT) ile tedavi etmek için harcanan ortalama süre 4 saat iken, yoğunluk ayarlıklı RT (YART) için harcanan süre ise 5 saat 45 dakika olarak bulunmuştur. Devlet hastanalerinde tüm hasta grubunda 3BKRT ve YART için harcanan süre üniversite hastanelerine göre daha yüksek bulunmuştur. Yeni RT tekniklerinin artan kullanımına paralel olarak, hastaların tedavisi için harcanan süre de de artmaktadır. Yeni RT tekniklerinin hastaların yararı için uygulamak için, yeterli ekipman ile birlikte, uygun ve eğitimli ekip gerekmektedir.

Anahtar Kelimeler: İnsan gücü, Radyoterapi donanımı, Personel, Harcanan süre

INTRODUCTION

Radiotherapy (RT) plays an important role in the treatment of cancer, together with surgery and chemotherapy. With more conservative managements and organ-sparing surgical procedures, RT use increases.[1,2] Modern RT techniques allow for improved dose distributions and more precise delivery of the treatment, which may potentially result in less toxicity with improved local control. Besides adequate equipment, sufficient and well-trained staff is required to achieve these benefits for the patients.[3] However these tremendous development in RT techniques and devices within the last two decades also imply major change in workflow, mainly target volume delineation and treatment planning.[4-6] Although a few studies have analyzed the required equipment and manpower that is assumed to be necessary to deliver RT with multicentric analysis, none of these recommendations were based on nation-wide evaluations.[5,7]

In Turkey, RT services are mostly provided by public university hospitals and state-run hospitals. The number of centers providing modern RT techniques with linear accelerators using 3-dimensional conformal RT (3DCRT), intensity-modulated RT (IMRT), image-guided RT (IGRT), stereotactic RT (SRT)and stereotactic body RT (SBRT) has been substantially increased after the year 2000, within the scope of 'National Health Transformation Program'.[8] Although 3DCRT has become the mainstay in many centers, the use of IMRT and IGRT has also been increased nationwide, reaching nearly 30% in all centers.[8] This increased usage of newer techniques demands for experienced physicians as well as medical physicists. The other important issue with the usage of these newer RT techniques is the increased time required for RT planning and delivery workflow, which has not been well studied yet. Therefore, it is essential to define the current situation nationwide in order to make strategic planning for the future so that the new techniques for RT planning and delivery are adopted without losing quality with adequate staffing.

The aim of this study is to analyze current status and workload of RT centers in Turkey on behalf of Turkish Society for Radiation Oncology (TSRO), by assessing time and staff required during core treatment procedures in patients with different tumor sites. In the future, this data will be the foundation for the strategic policy making and planning of more robust predictions for residency training and workforce requirements

MATERIALS AND METHODS

A survey consisting of questions on the number of medical staff and the treatment technique being used as well as the time spent for preparing and treating patients according to the tumor site was prepared. The survey was sent via e-mail to be re-

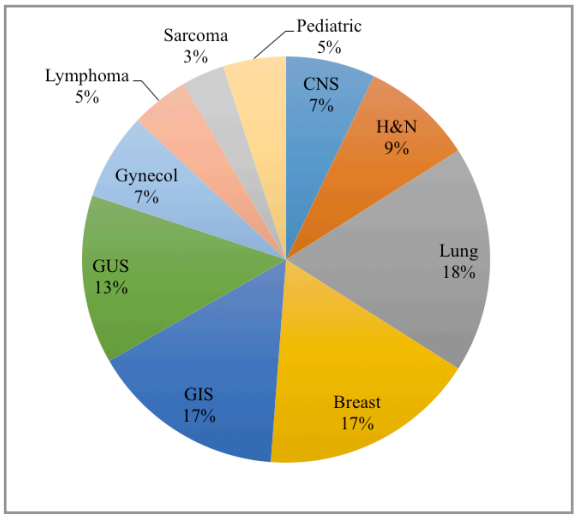

Figure 1. The incidence patients treated with radiotherapy in Turkey according to tumor site.

turned within one month to all university hospitals and state-run hospitals that are actively treating patients with RT. The survey consisted of two parts. First part aimed to find out about the number of radiation oncology specialists and residents, medical physicists, and total number of patients treated in each center per year. Second part aimed to find out about the details on type of the techniques being used and the time spent for treatment planning and delivery for the different techniques according to different tumor sites. This includes patient evaluation, contouring the target volumes and organs at risk, treatment planning, patient set-up and delivery of radiation. The survey questions were answered by an experienced physician for each hospital based on the 2012 year data. The data was to be reported by tumor site and the technique being used (3DCRT or IMRT). The centers also being asked to calculate the workflow time defined as the time required to evaluate, treatment planning and treatment of patients according RT techniques for all cancer types. The results were evaluated by several variables, the type of the center (university hospitals or state-run hospitals) and the number of patients treated per year per center (<1000 patients/year treated vs.≥1000 patients/year treated).

All data were collected at 'Education and Accreditation Committee' on behalf of TSRO and statistical analysis was completed using SPSS, version 20.0, program. Descriptive statistics and frequencies were produced for quantitative, categorical, and scaled variables, respectively.

RESULTS

Staff and Patients

The survey was sent to 48centers (38 university hospitals, 10 state-run hospitals) and the return rate was 71% (34 centers). Of the returned surveys 26 (76%) were university hospitals and 8 (24%) were state-run hospitals. Total number of specialist and residents for these 34 centers was 227 [median 5 (range: 1-30)] and 59 [median 2 (range: 1-8)], respectively; where residents were present in 27 of 34 hospitals (79%). Total number of physicists was 138, [median 3 (range: 1-14)].

Total number of patients attended to these 34 centers in 2012 was 242.500 with median of 5900 (range: 1716 - 38000) and the total number of treated patients was 37.769 with median of 1000 (range: 30 - 3138). As demonstrated in Figure 1, most frequent tumor types treated were lung, breast, gastrointestinal system, genitourinary system and head & neck tumors, which totally constitute nearly 75% of all cancer types.

One physician on average treated 192 daily courses per year (range: 41 - 650). Median number of patients treated by one radiation oncology specialist per year was 210 (range: 79 - 650) in the university hospitals and 101 (range: 41 - 167) in the state-run hospitals (Figure 2A). Fifteen centers (44%) treated <1000 patients/year and 19 centers (56%) treated ≥1000 patients/year (Figure 2B).

RT Workflow Time

Radiation oncologist spent a median of 4 h for 3DCRT and 5 h 45 min for IMRT treatment (Figure 3) for the workflow as defined above. Patients with HNC (6 h with 3DCRT, 9 h 45 min with IMRT) followed by prostate cancer (3 h 25 min with 3DCRT, 6 h 20 min with IMRT) and breast cancer (4 h 40 min with 3DCRT, 5 h 30 min with IMRT) were given more time for evaluation and treatment. It was evident that treating patients with IMRT required longer time compared to 3DCRT,

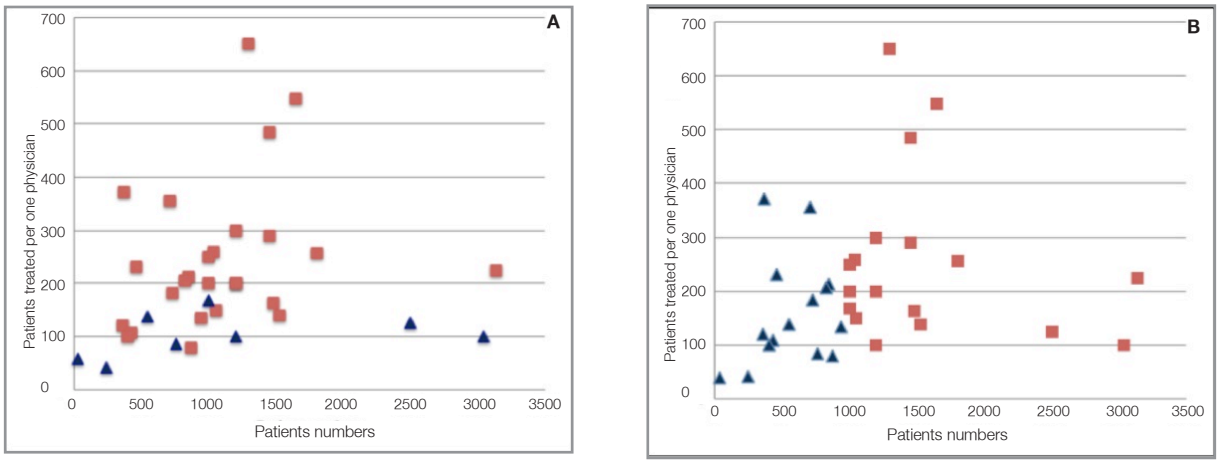

Figure 2. Patients treated per one physician. **(A)** according to university hospitals (rectangle) and state-run hospitals (triangle), and **(B)** according to low-patient workload (triangle) and high-patient workload (rectangle).

with most difference observed during contouring and treatment planning and evaluation. The biggest difference between 3DCRT and IMRT plans was observed in patients with HNC (2 h vs. 6 h) and prostate cancer (1 h vs. 3 h).

The percentage of patients treated with 3DCRT and IMRT was similar in university hospitals and state-run hospitals (Table 1A). However, IMRT was more frequently used for patients with lung, prostate and GIS cancers in university hospitals; whereas in state-run hospitals, IMRT was more frequently preferred for breast cancer and HNC patients compared to university hospitals. The time spent for all cancer types treated with 3DCRT and IMRT was higher in state-run hospitals compared to university hospitals. Most significant difference in time spent for contouring between state-run and university hospitals was observed in HNC and lung cancer patients treated with 3DCRT (Figure 4A). In IMRT treatment, the difference in contouring and planning time was observed in HNC patients (Figure 4B).

The percentage of patients treated with IMRT was somewhat higher in centers treated ≥1000 patients/year compared to centers treated <1000 patients/year (Table 1B). However, IMRT was more fre-

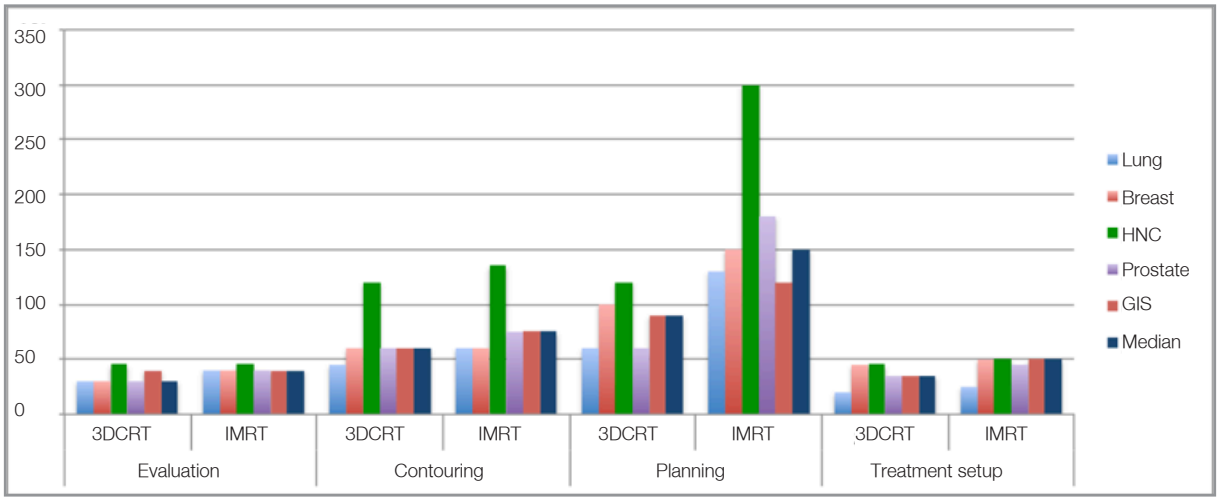

Figure 3. Time required evaluating patient, contouring volumes, planning treatment and patient set-up according disease site with different radiotherapy techniques.

Table 1. The percentage of patients treated with IMRT or 3DCRT according to diagnosis, and time required to prepare and treatment patients **(A)** in state-run and university hospitals and **(B)** in hospitals with low- and high-patient workload.

Table 1A

	Patient (%)				Time (min)			
	3DCRT		IMRT		3DCRT		IMRT	
Diagnosis	UH	SH	UH	SH	UH	SH	UH	SH
Lung	79.3	87.5	20.7	12.5	225	295	225	340
Breast	67.8	54.9	32.2	45.1	260	315	310	370
HNC	49.6	45.4	50.4	54.6	360	385	540	570
Prostate	31.7	43.4	69.3	56.6	245	215	360	390
GIS	69.7	80.0	30.3	20.0	265	250	295	305
Median	59.6	62.2	40.4	37.8	260	295	310	395

Table 1B

	Patient (%)				Time (min)			
	3DCRT		IMRT		3DCRT		IMRT	
Diagnosis	<1000 pts/yr	≥1000 pts/yr	<1000 pts/yr	≥1000 pts/yr	<1000 pts/yr	≥1000 pts/yr	<1000 pts/yr	≥1000 pts/yr
Lung	79.6	82.9	21.4	17.1	320	220	380	360
Breast	62.9	61.2	37.1	38.8	305	260	370	320
HNC	68.4	46.2	31.6	53.8	475	295	670	560
Prostate	45.4	28.9	54.6	71.1	320	225	435	325
GIS	65.5	73.0	34.5	27.0	315	255	380	305
Median	65.5	61.2	34.5	38.8	320	225	380	325

Abbreviations: 3DCRT= Three dimensional conformal radiotherapy, IMRT = intensity modulated radiotherapy, HNC = head and neck cancer, GIS = gastrointestinal system, pts/yr = patients per year.

quently used for patients with HNC and prostate cancer patients in centers treated ≥1000 patients/year compared to centers treated <1000 patients/year. The workflow time spent for both 3DCRT and IMRT treatments for all cancer types was higher in centers treated <1000 patients/year compared to centers treated ≥1000 patients/year; with most significant difference observed in HNC and prostate cancer patients. The difference in workflow time spent between centers treated <1000 patients/year and centers treated ≥1000 patients/year was observed in contouring and planning for all cancer types with 3DCRT (Figure 5A) and IMRT (Figure 5B).

DISCUSSION

This study was designed to assess the current status ofthe number of physicians and physicists working in each hospital, the workload of each department, and the workflow time for each RT facility by tumor types in radiation oncology departments that are actively treating patients in Turkey, unlike previous studies[4,9], which were mainly focused on a couple of hospitals, our study represents majority of radiation oncology departments workforce survey nationwide, which will serve as a baseline assessment for the future analysis and national planning strategies.

The results of the ESTRO project - Radiation Therapy for Cancer: QUAntification of Radiation Therapy Infrastructure and Staffing Needs (QUARTS) – recommended one radiation oncologist is needed for 200 - 250 patients/ year, and one physicist is required for 450 - 500 patients per year.[9,10] According to QUARTS, in 9 out of 13 European countries studied, including large countries like Germany, Italy, and England, the capacity of

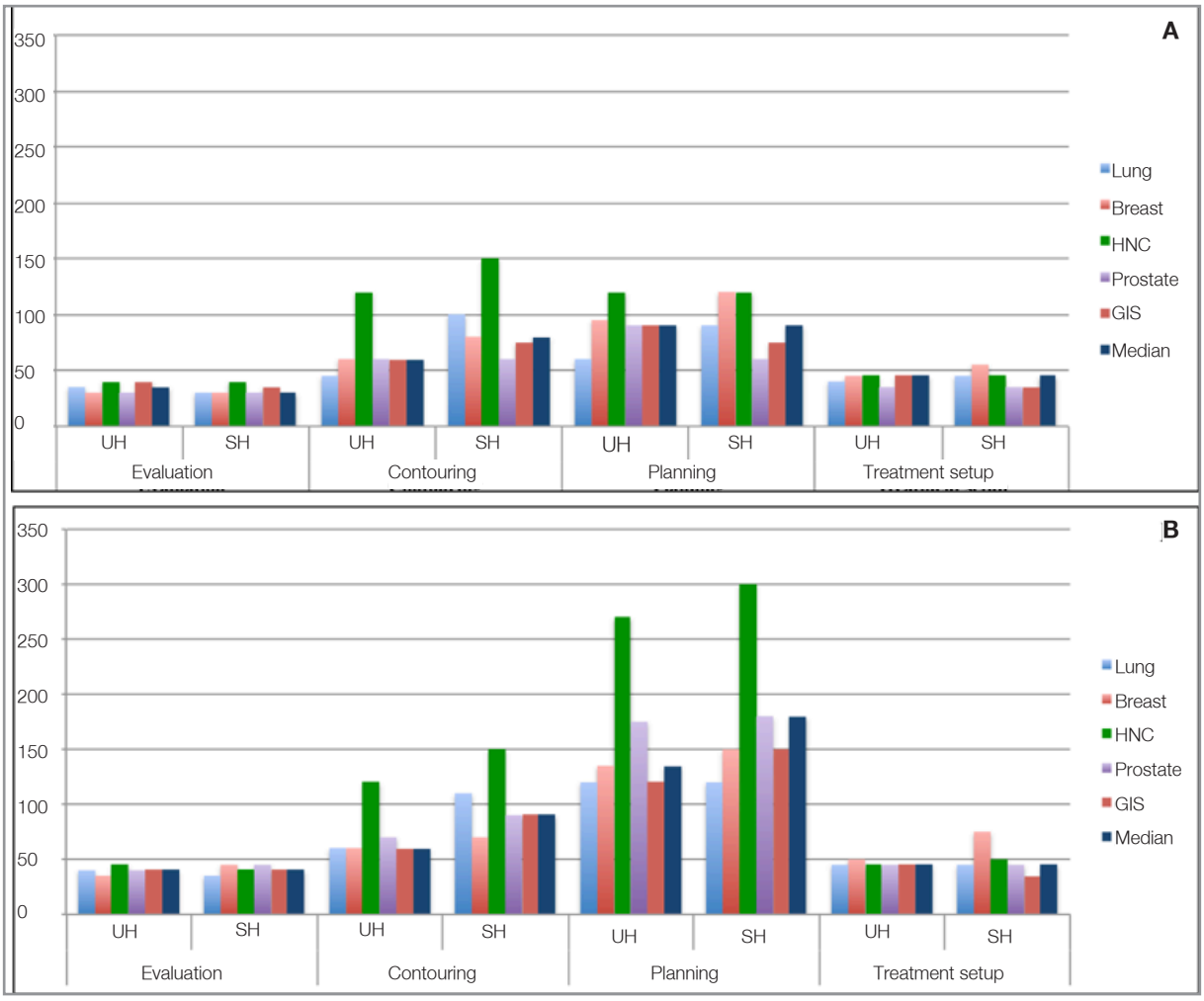

Figure 4. Time required evaluating patient, contouring volumes, planning treatment and patient set-up in university hospitals and state-run hospitals according disease site **(A)** with 3DCRT and **(B)** IMRT.

available RT units was more than 20% below the requirements. ESTRO Health Economics in Radiation Oncology[11] project analyzed RT staffing and annual number of treatment courses from 24 of the 40 European countries defined by the European Cancer Observatory. According to this report, one radiation oncologist treated median 209 courses per year (range: 100 - 349), and in countries with higher gross national income (GNI) per capita, physicians treated fewer courses per year than in less affluent countries. In this study, there were some differences in patients treated by one physician per annum between university hospitals (median 210, range: 79 - 650) and state-run hospitals (median 101, range: 41 - 167), which should be potential inhomogeneous distribution of physicians.

The number of patients treated by one radiation oncologist was higher (median 258; range: 200 - 650) than ESTRO recommendations in 17 university hospitals (65%) whereas none of the physicians at state-run hospitals treated more than 200 - 250 patients/year (Figure 2A). Five of 15 centers with <1000 patients/year (15%) treated less patients per year than ESTRO recommendations, while 12 of 19 centers with ≥1000 patients/year (35%) treated more patients per year than ESTRO recommendations (Figure 2B).

The components of the ESTRO QUARTS project that evaluated RT infrastructure and staffing requirements within the European countries.[9] The authors suggested estimates of radiation oncol-

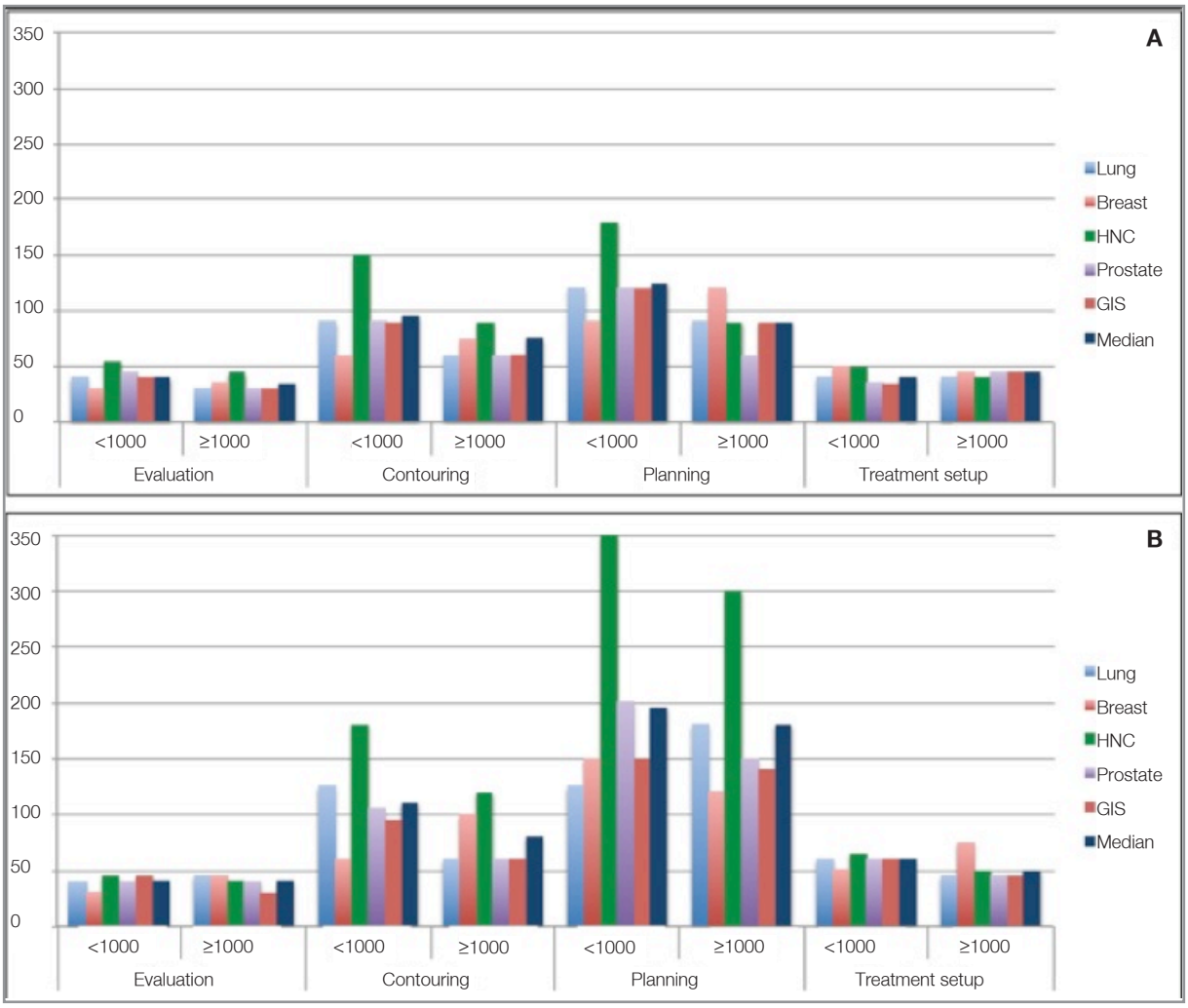

Figure 5. Time required to evaluate patient, contour volumes, planning treatment and patient set-up in low-patient workload and high-patient workload hospitals according disease site A. with 3DCRT and B. IMRT.

ogy human resources planning based on a ratio of radiation oncologists to annual patient load. With advent of modern RT techniques, improved dose distributions and more precise delivery of the treatment will possibly result in less acute and late toxicity together improved survival. For this purpose, besides adequate equipment, sufficient and well-trained staff is required to achieve these benefits for the patients.[3,5] Additionally, with more sophisticated techniques such as IMRT or SRT/SBRT, the medical staff needs longer time to treat patients properly. In a study conducted by German Society of Radiation Oncology (DEGRO-QUIRO study), the time required for RT with IMRT in patients with different tumor entities was evaluated.[5] They found that the total workload for the preparation of the treatment (definition of target volume, treatment planning, and approval of the treatment plan) required the most time for head and neck cancer patients (5 h 39 min), followed by prostate cancer patients (5 h 24 min), and breast cancer patient (4 h 19 min). Additionally, they pointed out that IMRT techniques were very complex and require much more time for preparation than 3DCRT did. In our study as demonstrated in Table 1, there is approximately one-hour difference between median total time required to prepare and treat a patient with 3DCRT compared to treat with IMRT compared to the DEGRO-QUIRO study. The difference is more prominent in patients with head and neck cancer and prostate cancer patients, where more than 50% of patients with head and neck cancer and pros-

tate cancer were treated with IMRT. The long time needed is probably due to complex anatomy, high number of organs at risk, large extent of the target volume, and higher radiation doses delivered without increasing the toxicity. Although the rates of patients treated with 3DCRT and IMRT were similar in university hospitals and state-run hospitals, the median time spent for treating a patient with IMRT is higher in state-run hospital compared to university hospital, with most prominent difference seen in breast cancer and lung cancer patients.

There are additional challenges more specific to radiation oncology workforce planning. These are, growth in cancer incidence, potential changes in indications for RT, potential changes in complexity of workload with the increased use of new technologies, and the lack of predictability in residency enrollment. A study by Smith et al.[12] suggested that the predicted increase in cancer incidence, partly due to a rise in the number of elderly and minority patients, would lead to a 22% increase in radiation oncology demands by 2020 in the United States. In Turkey, the size of population above 45 is estimated to be 34 % of whole population in 2023.[13] 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 RT is expected to reach 170.000 to 185.000 patients by 2023 in Turkey.[14] Furthermore, implementation of advances in treatment technology (e.g., IMRT, SRT/SBRT, and complex brachytherapy) is becoming commonplace, and the next decade could well see changing demands on radiation oncology professional time based on these changes, or could see increased use of other healthcare professionals. A study was conducted in Canada to develop and validate a workforce-planning model that would forecast the balance between supply of, and demand for, radiation oncologists in Canada over a minimum 10-year time frame.[15] The policy makers in Turkey believe that there is an excess number of radiation oncologists in our country up to year 2023.[14] As a result, only a limited number of new residents will be allowed despite a rising patient numbers in hospitals and increasing time required for newer RT techniques; such as IMRT and SRT/SBRT. However, this strategy will cause chaos during adaptation of new RT modalities, which requires more staff with higher knowledge and experience. Thus, with systematic planning program, the lack of adequate number of staff with appropriate knowledge for performing complex treatment will be diminished, and radiation oncology departments treated patients more efficiently at both state-run and university hospitals in accordance with patient workload.

This study is not without any limitations. First, there may be some bias due to self-reported responses. Secondly, the workforce doing different parts of planning differs hospital by hospital, for example, in some hospitals, dosimetrists or physicist make the contouring. For this reason, a detailed analysis of including all staff contributing the RT facilities; physicists, dosimetrists, RT technicians or nurse, should be required for further studies. Lastly, this study is based on mostly 3DCRT and IMRT. But with more sophisticated RT techniques, such as SRT/SBRT, intraoperative RT and complex brachytherapy applications, much more time is required, especially for treatment planning and patient setup; which will be a subject for another analysis in future.[16,17] However, the importance of this study is that, this is the first national review of the workload of RT centers and radiation oncologists and the time required for the workflow in Turkey. Also, this analysis represents major university and state-run hospitals which treats majority of patients, that makes the results more consistent and reliable.

CONCLUSION

Increasing cancer incidence and increasing utilization rates predict greater caseload demand that must be met by adjusting intake and retention of radiation oncology trainees. Discordance between supply and demand may cause loss of treatment quality, inadequate use of equipment and loss of workload and national supplies. In parallel with new RT facilities, which is very expensive for our country, future planning is essential to make the best RT facilities available nationwide to serve all regions of Turkey and its entire population equally, which requires more staff with acceptable experience.

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