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Research Article

A STUDY ON THE AVAILABLE FACILITIES AND WORKLOAD IN A RADIOTHERAPY DEPARTMENT AT A TERTIARY CARE TEACHING HOSPITAL IN NORTH INDIA

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A B S T R A C T

Background: Effective radiotherapy delivery relies on the synergy of optimized physical facilities and efficient workload management within a radiotherapy department. Through comprehensive assessments of spatial layout, equipment availability, and patient flow, we elucidate the impact of physical facilities and workload on treatment efficacy. **Materials and Methods:** A prospective observational study conducted for one year from January 1st 2021 to 31st December 2021, supplemented by review of records and interview of concerned personnel was conducted in the Department of Radiation Oncology. A checklist predesigned with references from International Atomic Energy Agency was used to study the various physical facilities and workload of each equipment i.e. Linear Accelerator, Theratron780E, Bhabhatron II TAW and CT Simulator in the Department of Radiation Oncology. A pilot study of fifteen (15) days was conducted to validate the tool. The data was collected as per predesigned checklist and was subjected to systematic analysis. The frequencies and percentages were calculated and represented graphically in the form of tables, bar diagrams. **Results:** the study observed that the department of radiotherapy had adequate facilities for providing various modalities of treatment and that there is a huge workload on all the equipment in the department. **Conclusion:** Utilizing a combination of quantitative metrics and qualitative observations, this research unveils the pivotal role of well-designed treatment rooms, advanced technology integration, and patient-centric spaces in enhancing treatment precision. As the radiotherapy landscape continues to evolve, this study contributes to the ongoing pursuit of excellence in cancer care by addressing the intricate relationship between physical infrastructure and efficient workload management within a radiotherapy department.

INTRODUCTION

Cancer is an increasing health problem in India and worldwide. Cancer treatment is done by multi-disciplinary approach that includes collaboration between surgical oncologist, medical oncologist, radiation oncologist and hospital administrator. Radiotherapy (RT) or radiation oncology is an essential component for cure and palliation of cancer. The aim of radiation oncology department should be to provide compassionate, state of art, innovative high quality radiation treatment to cancer patients in the safest possible manner. In addition to certain physical facilities as per the laid down guidelines, the radiation therapy department in any well-established modern hospital should have at least two treatment modalities: a cobalt unit and a linear accelerator. Cobalt unit is used for deep radiation therapy and linear accelerator uses a recent technology to treat a wide range of cases [1]. Certain basic physical facilities like adequate space for each type of work, tactical housing and location of various facilities in such a manner as to regulate the patient traffic can enhance the proficiency of service [2]. Radiotherapy unit should include facilities such as radiotherapist room, physician's room, laboratory, mould room, simulator and treatment planning system [3].

Location

Radiotherapy departments are usually located on the periphery of the hospital complex to avoid radiation protection problems arising from therapy rooms being adjacent to high occupancy areas Proximity to adjunct facilities, ready access for in-patients and outpatients, and consolidation of all therapeutic radiological services is important.[4]

Physical facilities

- **Parking:** There should be adequate parking for patients and their families including a sufficient number of handicapped designated spaces.
- **Accessibility:** The facility should be accessible to patients including those with handicaps or disabilities.

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- **Waiting area(s):** There should be a comfortable waiting area sufficient for the needs of patients and their families. There should be two waiting rooms, one for male and one for females. The size about 100-150 sq. feet with toilet facility [5].
- **Reception/business areas:** There should be sufficient space for a reception area, record storage and business functions of the practice.
- **Restrooms:** There should be a sufficient number of restrooms for patients, their families and the staff including access for handicapped and disabled individuals.
- **Examination Rooms:** There should be adequate examination rooms for patient care and, ideally, an area for examination of stretcher- and wheelchair-bound patients. (3,4)
- **Simulation areas:** There should be an area for simulation of patient treatment fields. There may be a separate simulation room or it may be incorporated into other areas in the facility.
- **Treatment planning/physicist/dosimetry areas:** There should be adequate space for Treatment Planning, Physicist and Dosimetry functions performed on site.
- **Megavoltage treatment room(s):** There should be an appropriately shielded area for each megavoltage treatment unit in use. These areas should meet all applicable manufacturer, state and/or federal requirements. Each treatment room should be equipped with door interlocks, radiation monitors, video observation equipment etc.
- **Treatment aide fabrication areas:** There should be areas for fabrication of treatment aides for the practice. These areas may be in separate rooms or incorporated into other areas within the facility. When utilizing potentially hazardous materials appropriate facilities should be available and utilized.
- **Offices:** There should be sufficient office space for physicians, physicists and other supervisory personnel to carry out their functions.
- **Other areas:** In addition to the above areas, the practice facility should have space for storage, a break room (lounge) for staff and space for other needs of the practice.[4]

MATERIALS AND METHODS

The present study is a prospective and observational study, conducted in the Radiation Oncology Department of the hospital for a period of one year from 1st January 2021 to 31st December 2021.A predesigned checklist with references from International Atomic Energy Agency was used to study the various physical facilities in the Department. For calculating the workload prospective observational study supplemented by review of records was conducted in the Department of Radiation Oncology.Workload of each equipment i.e Linear Accelerator, Cobalt units, and CT Simulator was observed during the study period. The data was collected as per predesigned checklist

RESULTS

Location of the Department

The location of the Department was studied using the standards given in Table 1.

Table 1 Location of the Department

Feature	Standard	Present	Absent
Location	Is the Department at the periphery of hospital	**Yes**	
	Is there provision of future extension	**Yes**	
	Is there ready access for in patients and out patients	**Yes**	
	Is there consolidation of all therapeutic radiological services	**Yes**	

Access to the Department

The access to the Department was studied using the standards given in Table 2.

Table 2 Access to the Department

Feature	Standard	Present	Absent
Access	Is the entrance to the room through a shielded door or via a maze	**Yes**	
	Access to Radiotherapy facilities using radioactive sources and rooms where sources are used and stored are restricted to public	**Yes**	

Mazes

The mazes of the Department were studied using the standards given in Table 3.

Table 3 Mazes in the Department

Feature	Standard	Present	Absent
Mazes	Is it long and with small cross section	**Yes**	
	Is there a physical barrier such as normal gate door installed to discourage entry to the maze during patient treatment	**Yes**	

Door and Interlocks

The doors and interlocks of the Department were studied using the standards given in Table 4.

Table 4 Door and Interlocks

Feature	Standard	Present	Absent
Doors and Interlocks	Is there a barrier installed at the entrance to the maze or treatment room to restrict access during exposure	Yes	NO
	Is there a motorized door with manual means of opening in event of power failure		
	Is there an emergency means by which motion of the door is stopped	Yes	
	Can all the doors, gates, photoelectric beams and motion detectors be interlocked to treatment unit when there is exposure	Yes	

Treatment Control Area

The treatment control area of the Department was studied using the standards given in Table 5.

Table 5 Treatment Control Area

Feature	Standard	Present	Absent
Treatment Control Area	Is this area close to the entrance of the treatment bunker	**Yes**	
	Is control area sufficiently large to accommodate the control console and associated equipment	**Yes**	
	Are there computer terminals for record verification, electronic portal imaging, Hospital Information System and Dosimetry equipment as well as Closed Circuit TV monitors for patient observation	**Yes**	
	Is there clear access to any Dosimetry ducts	**Yes**	

Patient Observation and Communication

The patient observation and communication system of the Department was studied using the standards given in Table 6.

Table 6 Patient Observation and Communication

Feature	Standard	Present	Absent
Patient Observation and Communication	Is the operator able to visually monitor the patient during treatment with closed circuit TV	**Yes**	
	Are there two cameras as per recommendation	**Yes**	
	Are they situated at axis for optimum observation of the patient on the treatment couch	**Yes**	
	Are the cameras located far away from radiation source	**Yes**	
	Is there provision for two way communication between the treatment control area and the room		**No**
	Is there a patient activated alarm in case patient is unable to give an audible call		**No**

Radiation Warning Signs and Lights

The Radiation Warning Signs and Lights in the Department were studied using the standards given in Table 7.

Table 7 Radiation Warning Signs and Lights

Feature	Standard	Present	Absent
Radiation Warning Signs and Lights	Are there properly illuminated signs may have two or three stages	**Yes**	
	Is the controlled area with restricted access labelled appropriately	**Yes**	
	When set up, for radiotherapy treatment of a patient are the room lights dimmable	**Yes**	

Room Lighting and Alignment Lasers

The room lighting and alignment lasers in the Department were studied using the standards given in Table 8.

Table 8 Room lighting and alignment lasers

Feature	Standard	Present	Absent
Room Lighting and Alignment Lasers	Are they able to control the room lights and lasers from the treatment unit control pendant in the treatment bunker	**Yes**	
	Are there incandescent lights to be used for the dim level as per recommendations	**Yes**	

Security of Radioactive Sources

The security of radioactive sources in the Department was studied using the standards given in Table 9.

Table 9 Security of Radioactive Sources

Feature	Standard	Present	Absent
Security of Radioactive Sources	Are there protective doors	**Yes**	
	Are there protective walls	**Yes**	
	Are there interlocks	**Yes**	

External Beam Radiotherapy (EBR): Equipment for EBR

The equipment for External Beam Radiotherapy in the Department were studied using the standards given in Table 10

Table 10 External Beam Radiotherapy (EBR): Equipment for EBR

Feature	Standard	Present	Absent
External Beam Radiotherapy (EBR)Equipment for EBR	Imaging	**Yes**	
	Treatment planning	**Yes**	
	Treatment delivery	**Yes**	
	Quality assurance	**Yes**	
	Radiation safety	**Yes**	
	Is it in close proximity to the treatment room	**Yes**	
	Does it include standard and gynecological examination tables	**Yes**	
	is there head and neck examination chair		**No**
	Appropriate examination instruments and medical supplies		**No**

Simulator room

The facilities of the simulator room in the Department were studied using the standards given in Table 11

Table 11 Simulator room

Feature	Standard	Present	Absent
Simulator Room	Is it large enough to accommodate the simulator allowing the full range of motion of the treatment table	Yes	
	Is there a provision for dimming the room lights	Yes	
	Is there provision to store treatment devices and daily used quality assurance equipment	Yes	
	If the immobilization devices are to be fabricated in the simulator room, cabinet space to store supplies for their fabrication will be required	Yes	
	Is there a sink provided in this room		No
	Is there an x-ray viewing window	Yes	

Treatment Planning Room

The facilities of the treatment planning room in the Department were studied using the standards given in Table 12

Table 12 Treatment planning room

Feature	Standard	Present	Absent
Treatment Planning Room	Is it located in close proximity	Yes	
	Is there a provision for dimming the room lights	Yes	
	Is there provision to store treatment devices and daily used quality assurance equipment	Yes	

Simulator room

The facilities of the simulator room in the Department were studied using the standards given in Table 13.

Table 13 Simulator room

Feature	Standard	Present	Absent
Simulator Room	Is it large enough to accommodate the simulator allowing the full range of motion of the treatment table	Yes	
	Is there a provision for dimming the room lights	Yes	
	Is there provision to store treatment devices and daily used quality assurance equipment	Yes	
	If the immobilization devices are to be fabricated in the simulator room, cabinet space to store supplies for their fabrication will be required	Yes	

Treatment planning room

The features of the treatment planning room in the Department were studied using the standards given in Table 14.

Table 14 Features of treatment planning room

Feature	Standard	Present	Absent
Treatment Planning Room	Is it located in proximity to simulator room	Yes	
	Is it large enough to house the treatment planning computer with its video monitor, a printer and plotter, a digitized tablet and other computer equipment	Yes	
	Is there provision for supplies of paper and pens or ink for printer and plotter	Yes	
	Is there a L shaped arrangement of the digitizer tablet and video monitor		No
	Is there space provided for light boxes and a high intensity light for viewing CT scans and plain X rays	Yes	

Mould room

The features of the mould room in the Department were studied using the standards given in Table 15.

Table 15 Features of mould room

Feature	Standard	Present	Absent
Mould Room	Is there space for tools, block cutter and counter top workspace pouring and mounting of blocks	Yes	
	Is there storage space for supplies of Styrofoam, trays and shielding material for custom blocking	Yes	
	Is there adequate ventilation provided if shielding materials are melted in above area	Yes	
	Is the required space for a patient couch	Yes	
	Is there a sink with refuse trap available	Yes	

Waiting areas

The features of the waiting in the Department were studied using the standards given in Table 16

Table 16 Features of waiting areas

Feature	Standard	Present	Absent
Waiting Areas	Is it adjacent to the treatment room, with space for seating of about twelve people for each machine	Yes	
	Is there separate waiting area for attending clinics and those awaiting treatment	Yes	
	Is there an area provided for provided patients on stretchers adjacent to the treatment area (but they should preferably be separated from ambulatory patients)	Yes	
	Is there a provision of \appropriate changing facilities close to the entrance of the treatment room, and shielded from the view of other patients and visitors (can avoid patients having to undress in the treatment room)	Yes	

High Dose Rate Brachytherapy

The features of high dose rate brachytherapy unit in the Department were studied using the standards given in Table 17.

Table 17 High Dose Rate Brachytherapy

Feature	Standard	Present	Absent
High Dose Rate Brachytherapy	Is there a radiographic imaging system	Yes	
	Is there a treatment planning area	Yes	
	Is there a locked and fixed container or device holding source	Yes	

Equipment for Brachytherapy

The features of equipment for brachytherapy unit in the Department were studied using the standards given in Table 18.

Table 18 Equipment for Brachytherapy

Feature	Standard	Present	Absent
High Dose Rate Brachytherapy	Is there a imaging equipment	Yes	
	Is there a treatment planning equipment	Yes	
	Is there a treatment delivery equipment	Yes	
	Is there a quality assurance equipment	Yes	
	Is there equipment for radiation safety and source handling	Yes	

Security provisions for High Dose Rate and Medium Dose Rate Brachytherapy Sources

The security provisions for high dose rate and medium dose rate brachytherapy sources Department were studied using the standards given in Table 19.

Table 19 Security provisions for High Dose Rate and Medium Dose Rate Brachytherapy Sources

Feature	Standard	Present	Absent
Security provisions for High Dose Rate and Medium Dose Rate Brachytherapy	Is there a locked room to separate the container from unauthorized access	**Yes**	
	Is there provision to detect unauthorized access to or removal of the source/sources in use	**Yes**	
	Use of the source in a locked room or controlled area	**Yes**	
	Is there continuous surveillance of the source	**Yes**	

Personnel Requirements

The personnel requirements for Radiotherapy Department were studied using the standards given in Table 20.

Table 20 Personnel Requirements

Feature	Standard	Present	Absent
Personnel Requirements	Is there a Medical Director/Head (Board Certified in Radiation Oncology)	Yes	
	Are there Certified Radiation Oncologists	Yes	
	Are there Qualified Medical Physicists	Yes	
	Are there Certified Radiation Therapists	Yes	
	Is there Certified Simulation Staff	Yes	
	Is there certified Dosimetrist	Yes	
	Is there patient Support Staff	Yes	
	Is there Physician Assistant	Yes	
	Is there Certified Nursing Staff	Yes	
	Is there Administrative Support	Yes	

Workload

Workload of Linear Accelerator

The number of treatment sessions done in the whole year from 1st January 2021 to 31st December 2021 was obtained from the records. Total number of cases done were 13400.Maximum numbers of cases were done during the month of September (n=1209) while as minimum number of cases were done in month of June (n=866). Average number of patient treatments done per month is 1117 while as average number of treatments done daily on linear accelerator is 37.2

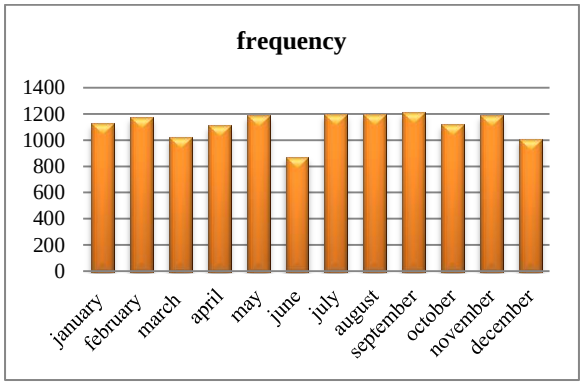

Figure 1 Number of treatments done on linear accelerator
Workload of Cobalt 60 units

The number of treatments sessions done in the whole year from 1st January 2021 to 31st December 2021 was obtained from the records. There are two Cobalt 60 units in the radiotherapy department.

Theratron 780E

Total number of treatments done was 12309. Maximum numbers of cases were done during the month of January (n=1115) while as minimum number of cases were done in month of August (n=900). Average number of patient treatments done per month on Theratron 780E is 1026 while as average number of treatments done daily is 34.2

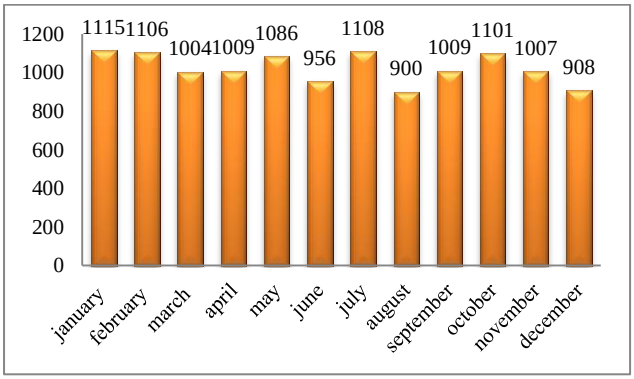

Figure 2 Number of treatments done on Theratron 780E
Bhabhatron II TAW

Total number of treatments done was 12709.Maximum numbers of cases were done during the month of October (n=1221) while as minimum number of cases were done in month of December (n=908). Average number of patient treatments done per month on Bhabhatron II TAW unit is 1059 while as average number of treatments done daily is 35.3

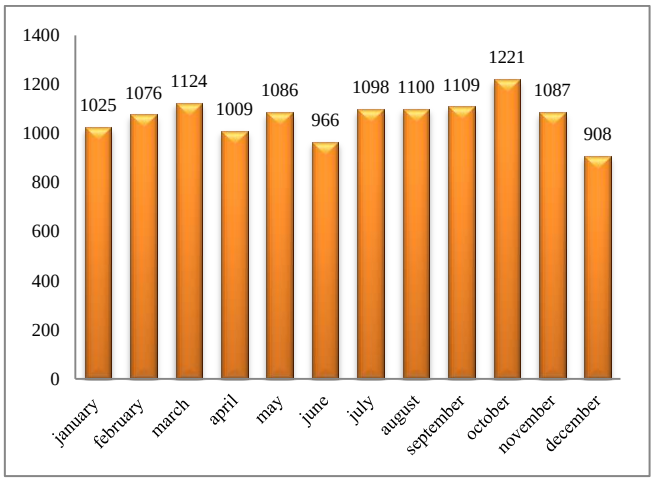

Figure 3 Number of treatments done on Bhabhatron II TAW

Work load CT simulator

The number of patients planned in CT Simulator for a period of one year was obtained from the records. Total number of patients planned in CT Simulator were 3360. Maximum numbers of cases were done during the month of January (n=350) while as minimum number of cases were done in month of November (n=287). Average number of patients planned per month is 280 while as average number of scans done daily on CT simulator is 9.3

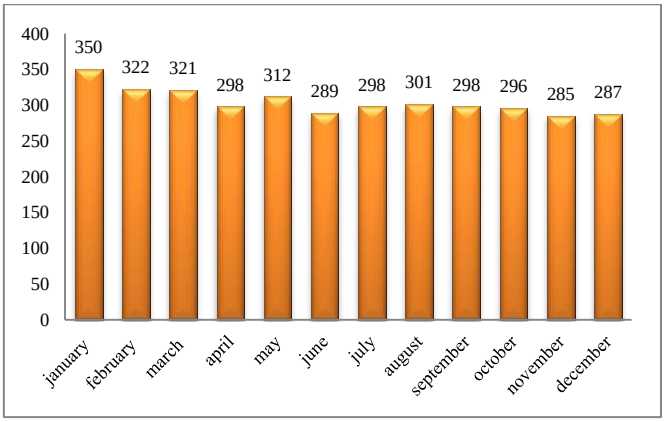

Figure 4 Number of patients planned on CT simulator Annual Workload of Linear accelerator, Cobalt 60 units and CT Simulator

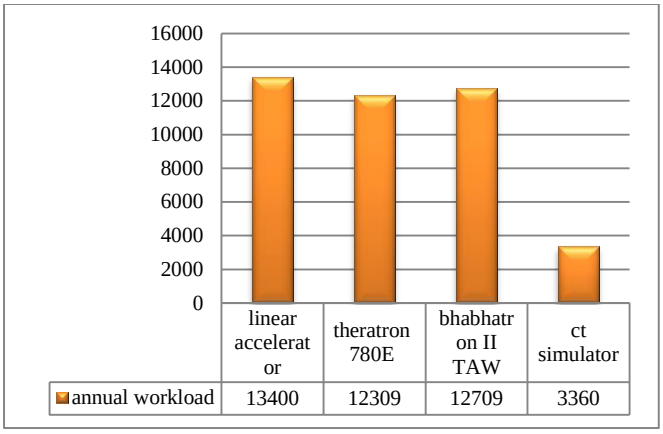

Figure 5 Annual workload of radiotherapy equipment

Average Monthly workload of Linear accelerator, Cobalt 60 unit and CT Simulator

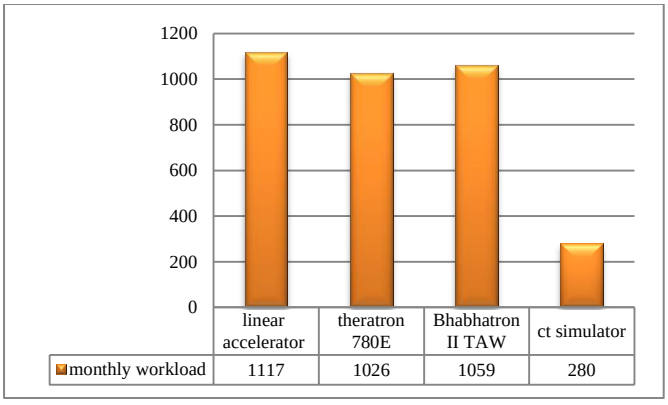

Figure 6 Average monthly workload of radiotherapy equipment

Average daily Workload of Linear accelerator, Cobalt 60 unit and CT Simulator

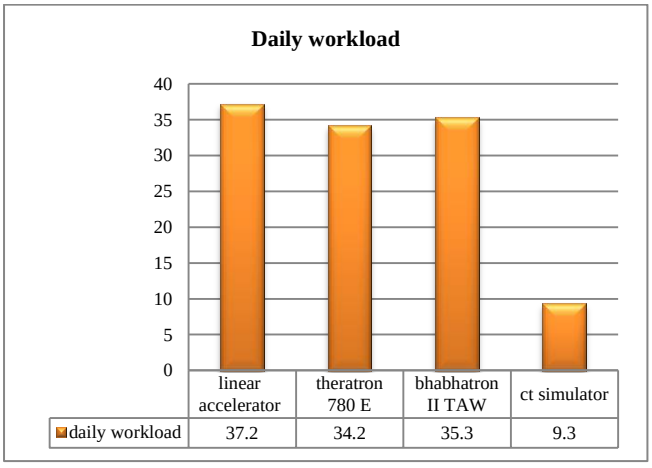

Figure 7 Daily workload of radiotherapy equipment

DISCUSSION

An observational study was conducted in the department of radiation oncology for a period of one year. A predesigned checklist was used to study the physical facilities available in the department. The checklist was designed as per guidelines of American college of radiation oncology. As per American college of radiation oncology[4], Radiotherapy departments must be usually located on the periphery of the hospital complex to avoid radiation protection problems arising from therapy rooms being adjacent to high occupancy areas. Proximity to adjunct facilities, ready access for in-patients and outpatients, and consolidation of all therapeutic radiological services. In our study it was observed that guidelines of national council for radiation protection[4,6] have been followed in the designing of the department. The department is located in the periphery of the hospital with ready access for inpatients and outpatients. There is consolidation of all therapeutic radiological services. The access to the department was studied using the American college radiation oncology/NPRC standards [4,6,9]. It was observed that there is restricted access to the treatment areas of the hospital and the entrance to the department is through a shielded/regulated door. The mazes of the department were studied using the American college radiation oncology/NRPC standards[4,7,8]. It was observed that mazes were long with small cross section with a physical barrier to discourage entry to the maze during treatment. The radiation warning signs and lights in the department were studied using the guidelines of international organization for standardization [10,11]. It is recommended to have illuminated warning signs at the different areas of the department. In our study radiation warning signs are properly illuminated with proper labelling of restricted areas. The treatment room lights were dimmable and adjustable. The room lighting and alignment lasers in the department were adjustable and can be dimmed as per requirement of treatments. The security of radioactive sources in the department it is of utmost significance. Guidelines of national council for radiation protection [4,5,7,8,12] recommended that radioactive sources must be stored under locks with restricted access limited only to authorized personnel. In our study it was observed that radioactive sources are under continuous surveillance within locked premises and with restricted entry. As per American college of radiation oncology[4,11,12] The external beam radiation therapy equipment include superficial equipments, Roth voltage machines, Bettors, linear accelerators , machine using isotopes (cobalt 60, cesium 137 machines).The study found equipment for imaging, treatment planning, treatment delivery, quality assurance, radiation safety and other supplies were as per NCRP guidelines [4,11,12].As per health building notes [8] ideally the simulation room should be positioned within a suit contains clinic areas, the mould room and planning rooms. The room should be square or rectangular to ensure that the wall laser light alignment is simple and accurate. The patient entrance should be wide enough for access for patient bed. Control area should be wide enough for several staff to be present as it is normal during simulation procedures. It is recommended that the area of 25 sq feet is a minimum[9]. There should be adequate bench space for any subsidiary computer system. Due to the number of computers and monitors it is advisable to have air conditioning to maintain acceptable working area. In our study it was there was adequate provision for storing of treatment devices, immobilization devices and there was provision for dimming of lights**.** As per health building note [8] the dominating nature of linear accelerator and mass of high-tech equipment presents a daunting experience for patients. Every opportunity should be taken with the interior design to create pleasant, non-intimidating with a sense of order and reassurance. Lighting in the treatment room also plays an important role. Murals and painting on walls and ceilings with decorative or entertaining features are value in occupying the patient mind and offering some measures of distraction. Art work should be considered at an early point in the design process to allow adequate and timely consultation with users on the suitability of the

proposals and production of the finished products. In our study it is observed that treatment room is in close proximity to other patient care areas. There is adequate provision of storing treatment devices and daily used quality assurance equipment. A waiting area of 100-150 sq ft is recommended as per MacGibbony's guidelines.[13] The features of the waiting areas in the department that were studied included availability of washrooms (separate for female and males), availability of wheelchairs and changing rooms in the waiting area. They were found in accordance with NCPR guidelines.[4,6,10,11,12,13]As per findings of C K Bomford [5], the design of brachytherapy include a sealed sources of laboratory, brachytherapy ward and remote after loading unit. In our study there was a radiographic imaging system, treatment room and treatment planning area in accordance with guidelines. The number of treatment sessions done in the whole year was obtained from the records. Average number of patient treatments done per month is 1117 while as average number of treatments done daily on linear accelerator is 37.2. Total number of treatments done was 12309. Average number of patient treatments done per month on Theratron 780E is 1026 while as average number of treatments done daily is 34.2 The decrease in the number of cases on Theratron 780E during some months of 2021 was due to reduction in activity of source which was later restored by replacement of source. Average number of patient treatments done per month on Bhabhatron II TAW is 1059 while as average number of treatments done daily is 35.3. The number of patients planned in CT Simulator for a period of one year was obtained from the records. Total number of patients planned in CT Simulator were 3360. Maximum numbers of cases were done during the month of January (n=350) while as minimum number of cases were done in month of November (n=287). Average number of patients planned per month is 280 while as average number of scans done daily on CT simulator is 9.3.

CONCLUSION

The present study observed that the department of radiotherapy had adequate facilities for providing various modalities of treatment. The physical facilities are per various standards laid down by the regulatory authorities. The study observed that the major equipment of radiotherapy department i.e CT simulator, Theratron, Bhabhatron II TAW and linear accelerator have a huge workload that can have a negative impact on treatment efficacy by causing frequent breakdowns.

Ethical Statement

This study was approved by the Institutional Ethics Committee of SKIMS with the Reference Number IEC/SKIMS Protocol # RP 169/2022. The written informed consent was obtained from the participants in the study.

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Conflict of Interest

The authors have no conflict of interest to declare.

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