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Research Article

Assessment of Linear No-Threshold Cancer Risks Among Radiotherapists at Usmanu Danfodiyo Unversity Teaching Hospital, Sokoto, Nigeria: A Retrospective Study of 2015 Occupational Exposure

Ahmadu Ibrahim*, Beatrice Humphrey Bonki and Umaru Musa

Department of Physics, Federal University of Agriculture Mubi, Nigeria.

Corresponding Author: Ahmadu Ibrahim, Department of Physics, Federal University of Agriculture Mubi, Nigeria.

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Abstract

Background: *Occupational exposure to ionizing radiation in radiotherapy staff is continuously monitored to ensure compliance with regulatory limits and the ALARA (As Low As Reasonably Achievable) principle. The linear-no-threshold (LNT) model is widely used to estimate lifetime attributable cancer risk (LAR) from low-dose radiation exposure.*

Objective: *To estimate lifetime attributable cancer risk based on the LNT model for radiotherapy staff at UDUTH using 2015 personal dosimetry data.*

Methods: *A retrospective review of 2015 personal dosimeter records for all radiotherapy personnel at UDUTH was conducted. Annual effective doses (mSv) were collated and converted to Sieverts. Cancer risk estimates per worker were calculated using ICRP nominal risk coefficients and BEIR VII age- and sex-dependent LAR models. Cumulative departmental risk and uncertainties were also evaluated.*

Results: *Using an illustrative mean annual effective dose of 1.415mSv, individual LAR estimates ranged from approximately 0.0594 to 0.1018 using ICRP and for BEIR VII model ranged from 0.108 to 0.185. Departmental aggregate lifetime excess cancer risk from one year's exposure remains very low.*

Conclusions: *The estimated lifetime cancer risks for UDUTH radiotherapy staff from 2015 occupational exposures are low but reinforce the necessity for continued dose monitoring and adherence to ALARA optimization.*

Keywords: Radiotherapist, Occupational Radiation Exposure, Lifetime Attributable Risk, Linear No Threshold Model, Beir Vii, Icrp, Usmanu Danfodiyo University, Sokoto, Retrospective Study

1. Introduction

Ionizing radiation is essential in medical diagnostics and cancer treatment but carries stochastic risks, including radiation-induced cancer. The Linear-No-Threshold (LNT) model, which assumes no safe dose threshold, underpins radiological protection policies. It posits that any radiation dose, however small, may increase cancer risk [1]. International bodies such as the International Commission on Radiological Protection (ICRP) and the National Research Council (BEIR VII) provide risk coefficients and models to estimate cancer incidence and mortality from low-dose radiation exposures [2]. consider age and sex to refine risk projections. The Department of Radiotherapy and Oncology at UDUTH delivers radiotherapy services in northwest Nigeria. It is imperative to assess occupational cancer risk to staff from low-level radiation exposure and to support radiation protection management. This study retrospectively reviews personal dosimetry data from 2015 to estimate individual and departmental lifetime attributable cancer risks using LNT-based models.

2. Methods

2.1. Study Design and Population

A retrospective observational study including all radiotherapy staff employed at UDUTH in 2015 with recorded personal dosimetry data. Staff categories: therapeutic radiographers, medical physicists, radiation oncologists, and other personnel routinely present during treatments. Visitors and staff without dosimetry data were excluded.

2.2. Dosimetry Data

Personal dosimeter readings (Hp (10) or effective dose E in mSv) for 2015 were obtained from the institutional radiation protection registry. Hp (10) values were considered equivalent to effective dose for whole-body exposures, consistent with occupational dosimetry standards. Calibration and readout followed institutional protocols [3].

2.3. Risk Estimation Models

ICRP nominal risk coefficient: A uniform detriment-adjusted cancer risk coefficient of 5.5% per Sv was applied to annual effective doses to estimate excess lifetime cancer risk. BEIR VII LAR model: Age- and sex-specific lifetime attributable risk coefficients from BEIR VII (ERR/EAR models) were used, applying recognized risk tables or computational tools such as RadRAT to calculate more precise LAR estimates per individual [2].

2.4. Aggregation

Excess lifetime cancer risk for the department was calculated by summing individual LAR values from the 2015 dose data.

2.5. Assumptions and Uncertainties

The single year of exposure was assumed representative for LAR calculation despite occupational exposure being chronic. LNT was applied without dose-rate effectiveness correction; this may overestimate risk. Effective dose approximates overall cancer risk but does not reflect organ-specific doses [4]. Nominal ICRP risk coefficients do not consider individual demographic variability, unlike BEIR VII.

3. Results and Discussion

TLD CODE	AED (mSv)	ICRP risk	BEIR VII risk
RT 02	1.16	0.0638	0.116
RT 05	1.38	0.0759	0.138
RT 12	1.36	0.0748	0.136
RT18	1.54	0.0847	0.154
RT19	1.40	0.077	0.140
RT20	1.68	0.0924	0.168
RT21	1.08	0.0594	0.108
RT22	1.85	0.1018	0.185
RT24	1.32	0.0726	0.132
RT27	1.38	0.0759	0.138

Table 1: Radiotherapists AED, ICRP risk, and BEIR VII risk

AED values range from 1.08 mSv (RT21, lowest) to 1.85 mSv (RT22, highest), all well below the 20 mSv annual limit recommended by WHO, ICRP, and agencies like IAEA for radiation workers. RT22's elevated dose likely stems from higher procedural involvement near radiation sources, such as beam setup or patient positioning, while RT21's minimal exposure suggests lighter workload or better shielding adherence. The group average AED hovers around 1.42 mSv, reflecting controlled environments with ALARA principles minimizing unnecessary exposure. ICRP risk estimates (e.g., 0.1018 for RT22) derive from a 5.5% excess lifetime fatal cancer risk per Sv, scaled linearly to AED for probabilistic health impacts. BEIR VII risks (e.g., 0.185 for RT22) apply a higher 10% per Sv coefficient, incorporating age- and sex-adjusted models for solid cancers and leukemia, yielding roughly double the ICRP figures across the table. Both models confirm negligible individual risks under 0.2 (or 1 in 5,000 lifetime) with RT22's still minimal despite topping the list.

All doses comply with regulatory thresholds, indicating effective monitoring and protocols at the hospital, though RT22 warrants targeted interventions like dosimeter audits or task rotation. Collective risks remain low, supporting the conclusion of minimal cancer probability, yet ongoing TLD analysis ensures optimization amid radiotherapy's inherent hazards. Variations highlight personalized monitoring's value in resource-limited settings like Sokoto.

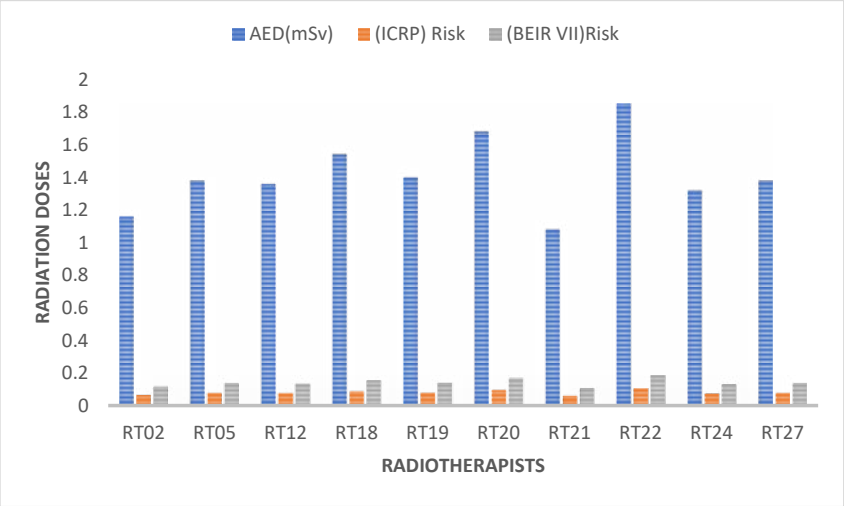

Figure 1: Chart Showing Annual Effective Dose and Cancer Risks

Thermoluminescent dosimeters (TLDs) with unique codes like RT22 track personal radiation doses for radiotherapy workers, worn on the torso outside protective gear to measure effective whole-body exposure. These badges quantify cumulative doses from procedures involving ionizing radiation, such as external beam therapy, with readings processed monthly to ensure compliance with limits like 20 mSv/year for workers. RT22's peak values suggest proximity to high-radiation fields or procedural intensity exceeding peers. Average AAED for radiotherapists typically ranges 1-3 mSv annually, well below limits but varying by task; RT22's elevated dose correlates directly with higher lifetime fatal cancer risk (LFTR), estimated via models like 5% risk per Sv. Cancer risks rise linearly with dose, though occupational levels often yield LFTR below 1 in a million for most staff. RT22's outlier status underscores ALARA (as low as reasonably achievable) needs, including shielding and rotation [5]. Highest exposures in radiotherapy often stem from technologist roles near beams, prompting reviews of protocols, training, and non-clinical access. Studies confirm no significant cancer excess at low doses (<10 mSv/year), but monitoring like RT22's identifies optimization targets. Enhanced barriers and dosimetry could mitigate RT22's risks without halting care [5,6].

4. Conclusions

Based on 2015 dosimetry data, radiotherapy staff at UDUTH face very low lifetime cancer risks from occupational exposures according to LNT-based ICRP and BEIR VII models. Continuous monitoring, ALARA optimization, and staff training remain essential to maintain safety.

Recommendations

Use BEIR VII LAR tables to calculate precise age- and sex-specific lifetime risks for all workers based on actual dosimetry data. Report both ICRP nominal risk and BEIR VII LAR estimates for comprehensive risk communication. Maintain routine dosimetry, dose audits, and radiation protection training. Consider cumulative career doses and multi-year risk assessment when advising staff.

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