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Determination of Gross Alpha and Beta Activity from Annual Effective Dose for Dental Medical Radiation Workers

Ahmadu Ibrahim

Physics Department, Usman Danfodiyo University Sokoto, Sokoto State.
Corresponding Author: ahmedmubi9133@gmail.com
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Key: annual effective dose, Alpha, Beta, Activity and Radiation.

Abstract

This study determine the annual effective dose, alpha and beta activity concentration of Dental medical radiation, at Usmanu Danfodiyo University Teaching Hospital (UDUTH) Data were sourced from the facility's radiation monitoring records and analyzed to determine the annual effective doses, alpha and beta activity concentration for each worker. The findings indicate that the annual effective doses ranged from 0.61±1.28 mSv, Alpha Activity ranged from 0.031±0.064Bq and Beta Activity ranged from 0.61±1.28 Bq per worker. These exposure levels with the exception of Surgeon Assistant who recorded the highest dose of 1.0 Bq the remaining Dental workers doses were within the recommended limits set by national and international standards, which are 5 mSv per year or an average of 20 mSv over five years. Consequently, the study concludes that there is no significant radiation-related risk to any workers for annual effective dose and alpha activity concentration in the study.

Introduction

Over a century ago, in November 1895, Wilhelm Conrad Roentgen discovered the X-ray. Not that long months later, in March 1896, Henri Becquerel described the radioactivity. The use of ionizing radiation has become increasingly frequent and diverse in the later decades. Today the radiation is used in many sectors of medical, industrial, military and research. Ionizing radiation is a type of radiation characterized by its short wavelength and high frequency, and its ability to produce free radicals (ions) when it interacts with matter (ICRP, 2007).. One of the hazards that health care professionals working in the nuclear medicine department face, is the possible ongoing exposure to ionizing radiation. Multiple standards have been developed in this area, not only to limit occupational exposure but also to mitigate the interplay between professional exposure to ionizing radiation and health incidences (Joseph et., al. 2017). Maintaining a low level of occupational radiation exposure has been the core concern of governments across the globe. These national limits are supported by other international standards including the International Atomic Energy Agency Mohsen et., al. (2014), the International Commission on Radiological Protection (ICRP), 2007) and the International Labor Organization whose principles are to offer protection to radiation workers and public can remove the tightly bound electrons from the shell of the exposed atom, causing the atom to become charged or ionized. This radiation consists of particles (e.g. alpha, beta and gamma) or electromagnetic waves (X-ray and gamma ray) that are energetic enough to cause ionization and severe biological damage when it absorbed by human tissues. Indeed, the high doses of ionizing radiation can cause mutation, cancer, radiation sickness, and death (Bahreyni et.,al 2018).

The ED or EDE is a quantity that takes into account that the various organs and tissues of the human body respond to radiation differently (RSSC.2011). It is used primarily in radiation protection, and is intended to compare the risk of stochastic effects associated with a non-uniform exposure to radiation with that of a uniform whole-body exposure. A stochastic effect is a health effect that occurs randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose (example: getting cancer) (EPA 2009). The ED is intended to estimate risk for radiation protection purposes only, and is not intended for calculating individual-specific doses. The ED is calculated by multiplying the equivalent dose (H_T) to each organ/tissue by the tissue weighting factor for that organ/tissue(W_R,) summed over all the organs/tissues in the body: $TTE = \sum wT \times H$ The unit for the ED remains the rem or Sievert (RSSC.2011)

METHODOLOGY

Data for this research were collected from three Departments of Usman Danfodiyo University Teaching Hospital Sokoto, Nigeria. Anonymized records of measured quarterly doses at the Dental department for the period from 2014 to 2018 were obtained. We obtained the documented records of the exposure doses of the medical radiation workers at Dental department of the Teaching hospital (UDTH) (Cember et.,al 2009). The collected sheets did not present the names of workers as required by the Health Research Ethics Board (HREB). Instead, each participants' names were replaced by a TLD code that could not expose the identity of the workers, yet make it easy to refer back at any phase of the research. The de-identified and coded records for medical radiation workers in the three departments, had the information on the quarterly whole body and extremity doses, the cumulative dose for each year was obtained. The average of the total doses obtained quarterly, gives the cumulative dose absorbed yearly. The National Dosimetry Services (NDS) was the dosimetry service provider for the facilities of the three departments at UDUTH.
To convert the output readings of TLDs from charge (nC) to absorbed dose (Gy); the following equations was used (Rahman *et al.*, 2016).

$$D = \frac{H_T}{W_R} \quad (3.1)$$

Where D = Absorbed dose
H_T = Equivalent dose
W_R = Radiation weighing factor

The time between irradiation and readout was kept the same to minimize fading from one calibration to another for all TLDs. The calibration factor is defined as follows:

$$f_{calibration} = \frac{D_{ionization\ chamber\ (mGy)}}{TLD_{reading\ (n)}} \quad (3.2)$$

Absorbed dose due to irradiation is obtained after background subtraction using equation 3.3

$$D_{TLD} = D_{av} - BG \quad (3.3)$$

The absorbed dose is obtained for each TLD using equation 3.4

$$D(mGy) = f_{cal}\left(\frac{mGy}{nC}\right) X\, TLD_{reading}(nC) \quad (3.4)$$

For all individual doses, the minimum detection level (MDL) is 0.05 mSv for 3 months after background subtraction Abu-Jarad, F. (2008). The MDL is a dose recording level, therefore worker who received doses lower than MDL is considered as unexposed. Shallow dose equivalent (Skin) and deep dose equivalent (DDE) generated by the TLD reader are manually entered into a Microsoft Excel spreadsheet to calculate the corresponding personnel dose equivalent values Hp (0.07) and Hp (10).

$$E_i(Sv) = \sum_T W_T \times H_T \text{ (EPA 2009)} \quad (3.5)$$

W_T: tissue weighing factor for organ T
H_T: equivalent dose received by organ or tissue T

$$GA/GB = \frac{E_i(Sv)}{WR\ x\ WT} \quad (3.6)$$

Where GA/GB are gross alpha and beta activity in Bq.

Results and Discussions

Table 1.0 Descriptive Statistics of AED, Alpha and Beta Activity of Medical Radiation Workers of the Same Cadre in Dental Department

Serial No	Dental workers	AED(mSv)	Alpha Activity(Bq)	Beta Activity(Bq)
1	Dental Surgeons	0.69	0.035	0.69
2	Asst. Surgeons	1.28	0.064	1.28
3	Technologists	0.61	0.031	0.61
4	WHO Limit	5.00	0.50	1.00

The results obtained from the table above signified that the annual effective dose received is in the range 0.61±1.28 mSv, less than the recommended value of 5.0mSv per year. The alpha activity is in the 0.031±0.06Bq the result showed that Surgeon assistant received the highest alpha concentration while the Technologists recorded the lowest concentration, all the values were less than the recommended value of 0.5Bq by WHO. For beta activity Surgeon assistant received the highest activity which was greater than the recommended limit of 1.0Bq, which will lead to cancer. The results obtained signified that Surgeon Assistant expose more to radiation.

Table 1.1 Tukey HSD Post HOC Test of AED of Different Cadres in Dental Department

(I) Dental Workers Comparison	(J) Dental Workers Comparison	Mean Difference (I-J)
Surgeon Assistant	Technologists	.6700
	SURGEON	.5820
Technologists	Surgeon Assistant	-.6700
	SURGEON	-.0880
Surgeon	Surgeon Assistant	-.5820
	TECHNOLOGISTS	.0880

The result for the comparison above showed, pairwise comparison between, Surgeon Assistant with Technologists and Surgeon yielded positive result, signified that Surgeon Assistant recorded the highest rate of exposure, while Technologist with Surgeon and Surgeon Assistant yielded negative results showing that Technologist rate of exposure to radiation is very low. The last comparison showed that Surgeon exposed more to radiation source than Technologists.

Conclusion

In conclusion, the study provides a comprehensive analysis of occupational radiation exposure among dental workers at Usmanu Danfodiyo University Sokoto Teaching Hospital, with doses significantly below the recommended safety limits. The comparisons with related studies from other countries demonstrate that the radiation safety measures at the hospital are effective and in line with international standards. Continuous monitoring and targeted interventions for roles with higher exposure will further enhance the safety and health of dental medical workers.

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