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ORIGINAL ARTICLE

Lifetime Risk of Radiation Induced Severe Hereditary Stochastic (SHS) Effects in Medical Radiation Personnel of INMOL Hospital, Pakistan

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ABSTRACT

Background: Hereditary risk assessments in medical radiation workers must be accentuated as a precaution against genetic diseases. Ionizing radiations can induce hereditary or genetic radiation effects.
Aim: To evaluate the lifetime risk of severe hereditary stochastic (SHS) effects in INMOL's medical radiation personnel.
Methods: The determination of the 'whole-body' effective doses was performed by 'dose assessment algorithm'. We adopted the procedure described by ICRP for the assessment of lifetime severe hereditary annual risks by using 'nominal probability coefficient'.
Results: The AAEDs were between 1.41-1.79 mSv (in NM), 1.07-1.43 mSv (in RT) and 1.21-1.70 mSv (in RD) during 2014-2018. A declining trend is observed in AAED values in five consecutive years, due to improvements in radiation protection and safety measures. The risks of severe hereditary effects were also decreased from 2014-2018. The SHS risk was decreased from 5.012×10^{-4} to 3.948×10^{-4} in NM, 4.004×10^{-4} to 2.996×10^{-4} in RT and 4.76×10^{-4} to 3.388×10^{-4} in DR department.
Conclusion: This study is emphasizing towards evaluating risks of hereditary effects from chronic exposure of radiations in occupational workers to avoid further late genetic complications. Such quantitative indicators would be useful in comparing other lifetime death risks from other harmful substances.
Keywords: Hereditary Stochastic Effects; Annual Average Effective Doses; Nominal Probability Coefficient; Medical Radiation; Occupational Radiation Risk Assessments

INTRODUCTION

Hereditary health risk assessments in occupational radiation workers must be accentuated as a precaution against genetic diseases. In current study, the annual average effective doses (AAEDs) were assessed in medical radiation workers of INMOL (Institute of Nuclear Medicine & Oncology, Lahore), Hospital and evaluated the lifetime risk of severe hereditary stochastic (SHS) effects during 2014-2018. Diagnostic and therapeutic radiations are extensively used to diagnose and treatment of various diseases. The epidemiological assessments have been emphasized in occupational medical radiation workers for the entire radiation safety and protection. It was mentioned that the probability of cancer and hereditary stochastic effects can increase at higher doses, but the severity might not be associated to the dose[1]. The UNSCEAR and ICRP have mentioned dose-effect IR related stochastic processes and methods. They mentioned the procedure to assess the lifetime risk of severe hereditary stochastic (SHS). A low-level chronic exposure from IR is considered potentially harmful as confirmed by epidemiological studies by the calculation of probabilities of causation and risk co-efficient for cancer or hereditary effects[2-3] .

Both deterministic and stochastic risks are related to cancer and hereditary effects with the exposure of IR. There is a great emphasis on late-health effects in people exposed to IR. Heritable genetic effects are being assessed from linear models of doses to generate models of genetic effects, e.g., a risk model was mentioned in UNSCEAR (2001). A chronic low radiation dose affects medical radiation workers annually, while providing radiation treatments to the cancer patients[4]. Different weighing factors and statistical analyses have been considered and employed by UNSCEAR and ICRP to assess the radiation exposures and risks of acquiring hereditary effects[3].

Ionizing radiations are known to induce hereditary radiation effects by impacting gonads. They can damage the genetic material by mutations and that can induce genetic diseases. Hereditary health risk assessments in occupational radiation workers must be conducted as a precaution against genetic diseases including cancers. Hereditary health assessments have been done in the Chernobyl cleanup workers' offspring and the results provided an evidence of radiation related hereditary effects at doses greater than 20 cSv[4].

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METHODS

The occupational exposure doses of medical staff were assessed from radiation departments. The data was collected and processed by the radiation dosimetry system for the assessment of medical radiation workers' exposure levels in following departments: Nuclear Medicine (NM),

Radiotherapy (RP) and Radiology (RD). A prior ethical approval was taken. The data of the radiation workers were collected on informed consents. The whole body annual average effective doses (AAEDs) were assessed through TLD dosimetry reader. 'RadLab' software and dose assessment algorithms were used to document the radiation doses. For stochastic effects, we endorsed the methodology mentioned by ICRP and UNSCEAR to assess the lifetime risk of severe hereditary stochastic (SHS) effects by using 'nominal probability coefficient'. The nominal probability coefficient for the stochastic effects of hereditary risk is 0.8×10^{-2} (detriment per Sv)[3]. The lifetime SHS effects were evaluated by the multiplication of mean yearly dose exposure by 35 years and the corresponding coefficient [3] .

RESULTS

The number of all radiation workers (50-59 in NM, 40-51 in RP & 16-25 in RD), their AAEDs and severe hereditary stochastic (SHS) effects are represented in Table 1. The AAEDs were between 1.41-1.79 mSv (in NM), 1.07-1.43 mSv (in RP) and 1.21-1.70 mSv (in RD) during 2014-2018. A declining trend was observed in AAED values in five consecutive years, due to improvements in radiation protection and safety measures. These exposures are well below the annual dose limit. Only three workers from NM & RD departments were found with AAED >12 mSv (within limit).

The radiology department workers deal with the frequent cancer diagnostic radiations and during treatment, the NM workers deal with the radionuclide generators and handle tens of Giga Becquerel radioactive material. In case of unsealed radiation sources used in NM department, the exposed radiation could be higher as compared to radiotherapy units (external beam therapy) which is protected and includes sealed sources. Moreover, during irradiation of the patients in radiotherapy treatments, the workers stay in shielded chamber, which protect them from leaked or scattered X-rays, except in microscopy technique where a physician stays close to the patient. Similarly, the risks of severe hereditary effects were also decreased from 2014 to 2018 in all workers (Figure 1). In King Abdul Aziz Radiation Protection department[5], the radiation workers were monitored and the AAEDs were: 0.66, 1.56 and 0.28 mSv in NM, RP and RD departments, respectively. The X-rays doses in medical staff in the cardiac catheterization laboratory in Taiwan was measured. The estimated annual doses in the staff were between 35.03-1.92 cSv, 1.95-0.06 cSv and 0.19-0.05 cSv[6].

Figure 1: Comparison of SHS in all departments (NM, RP, RD) from 2014 to 2018

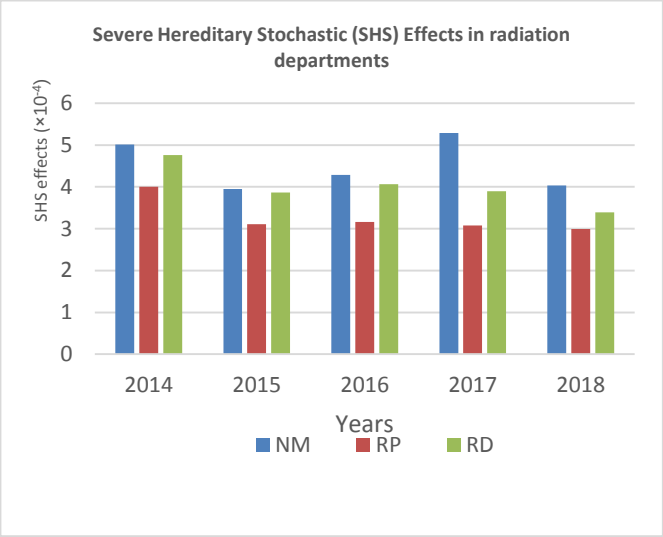

Table 1. AAEDs (mSv) And Severe Hereditary Stochastic (SHS) Effects During 2014-2018.

Years	Radiation departments and AAEDs								
	NM Department			RP Department			RD Department		
	Workers	*AAED*	*SHS*	*Workers*	*AAED*	*SHS*	*Workers*	*AAED*	*SHS*
2014	50	1.79	5.012×10^{-4}	40	1.43	4.004×10^{-4}	16	1.70	4.76×10^{-4}
2015	52	1.41	3.948×10^{-4}	43	1.11	3.108×10^{-4}	18	1.38	3.864×10^{-4}
2016	55	1.53	4.284×10^{-4}	46	1.13	3.164×10^{-4}	21	1.45	4.06×10^{-4}
2017	57	1.51	5.285×10^{-4}	48	1.10	3.08×10^{-4}	23	1.39	3.892×10^{-4}
2018	59	1.44	4.032×10^{-4}	51	1.07	2.996×10^{-4}	25	1.21	3.388×10^{-4}

DISCUSSION

The SHS risk decreased from 5.012×10^{-4} to 3.948×10^{-4} in NM, 4.004×10^{-4} to 2.996×10^{-4} in RP and 4.76×10^{-4} to 3.388×10^{-4} in RD department. The risk of SHS was higher (5.012×10^{-4}) in NM workers in 2014, however, which has been minimized (4.032×10^{-4}) in 2018 (Table 1). The risk was minimum in RP workers in 2018 (2.996×10^{-4}). The deterministic and stochastic risk of IR has been evaluated for cancer and hereditary diseases and it was concluded that although the relative risks of Japanese atomic-bomb survivors were higher than the medical radiation exposed workers, but the excess absolute risks can be higher in the radiation exposed workers[7].

Mutations induced from IR can impact the reproductive cells, which leads to the heritable diseases [8]. The hereditary effects emerge from 'germ-line mutations', is called stochastic effect [8] . Late-health effects of IR exposures have been derived from the studies of Hiroshima & Nagasaki. Although the risk of hereditary malformations and cancer in the children of atomic-bomb survivors did not increase, but an altered immune response was detected from paternal/maternal doses. Thyroid cancer was found in children several years after the incident of Chernobyl [8] . It has been emphasized regarding an estimation of hereditary impacts from ionizing radiations according to the epidemiological data collected BEIR [8] . Shaw et al. (2011) used the hereditary risk coefficients to estimate the risks after in utero X-ray exposure. They

estimated the hereditary effects in future generation could be 2.4×10^{-2} /Gy [9] . A review related to the assessment of gonad doses in patients and in occupational medical radiation workers via. interventional fluoroscopy has been provided by Latini et al. (2012) [10] . It was estimated that the gonad doses can be received up to ten-folds from interventional procedures with a cumulative exposure of up to 1 mSv in the entire work lifetime of the professional interventionists. Radiation induced hereditary risks needs to be extenuated in radiation exposed workers to protect their offspring.

CONCLUSION

Both deterministic and stochastic risks are related to cancer and hereditary effects with the exposure of IR. The severe hereditary stochastic (SHS) effects risks were decreased from 2014 to 2018. There is still no potential stochastic study available to affirm the hereditary health risks from the long term exposure in existing radiation workers. The quantitative indicators are useful in evaluating risks of hereditary effects from chronic exposure of radiations in occupational workers to avoid further late genetic complications. Future work can be done to devise a robust technique of an early diagnosis of any developmental hereditary genetic disease in occupational radiation personnel.

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