Development of radiation monitoring services for radiation workers in Saudi Arabia

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Abstract

The Biomedical Physics Department at King Faisal Specialist Hospital and Research Centre was established in 1980. This report evaluates the Health Physics Section services for all radiation workers in Saudi Arabia during the period between 2006 and 2012. In 2012, a total of 19,054 Thermoluminescent Dosimeter chips were issued compared to 2,480 TLD chips in 2006. The Secondary Standards Dosimetry Laboratory has calibrated 1,075 survey meters in 2012 compared to 356 in 2006. In 2012, the radiation biodosimetry laboratory has been established and constructed a dose calibration curve. This report shows the improvement of radiation monitoring services in Saudi Arabia.

Keywords: radiation workers, radiation protection, health physics, radiation biodosimetry, Saudi Arabia.

1 Introduction

The Biomedical Physics Department (BPD) at King Faisal Specialist Hospital and Research Centre (KFSH&RC) was established in 1980. The BPD mission is to seek, apply, and disseminate concepts and methods for effective and safe use of radiation in diagnosis and treatment of human diseases, and to continue improving and expanding such use through clinical research activities. In addition, it aims to monitor and provide expertise in radiation protection of staff, patients, public and the environment and maintain the personnel radiation-dose monitoring system.

The BPD consists of seven sections: Health Physics, Radiation Oncology Physics, Imaging Physics, Radiation Biology, Secondary Standards Dosimetry Laboratory (SSDL), Radiation Safety Office and Gamma Irradiation Facility

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(Fig. 1). These sections provide services in radiation oncology, radiology, radiation biology, radiation protection and safety services.

The radiation monitoring services for radiation workers are dedicated completely or partially to Health Physics Section, Radiation Safety Office and Secondary Standard Dosimetry Laboratory.

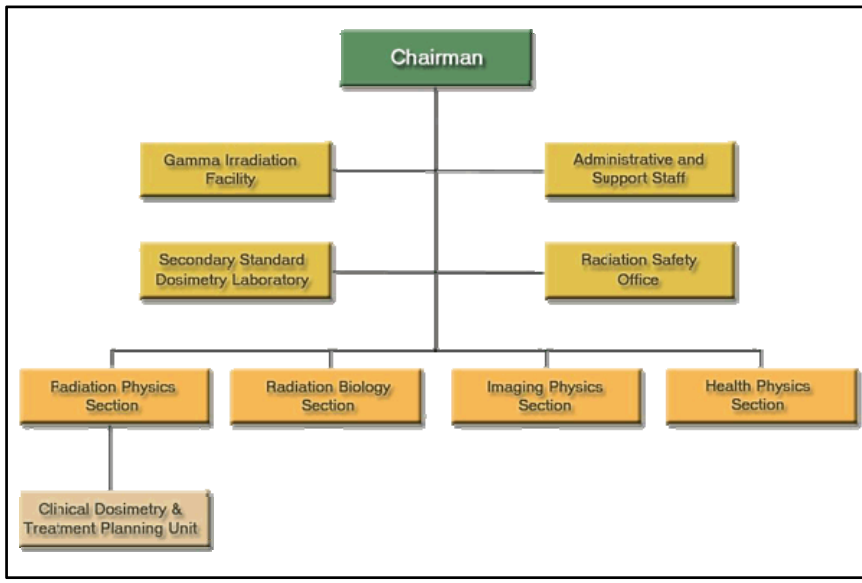

Figure 1: Organizational structure of Biomedical Physics Department at King Faisal Specialist Hospital and Research Centre.

The Health Physics Section established a national reference radiation monitoring laboratory based on Thermoluminescent Dosimetry (TLD) which is obeying the regulations of the International Commission on Radiological Protection (ICRP) No. 60 (1990) dose limits for occupational workers and members of the public [1], and it is licensed by Saudi regulatory agency which is King Abdulaziz City for Science and Technology (KACST) in order to monitor and reduce the radiation exposure received by radiation workers in Saudi Arabia. Although, 90% of Saudi radiation workers received less than half of the recommended occupational radiation dose limit, radiation monitoring services are an essential estimating system in case of radiation accident [2]. In addition, the Health Physics Section performs periodic monitoring of radiation areas and measures, with portable or fixed instruments, fields of radiation, air or water-borne radioactivity, movement of radioactive material and possible radioactive contamination. Moreover, the Health Physics Section issues pocket dosimeters for radiation workers working on non-routine procedures, or when immediate radiation dose assessment is needed.

The establishment of the Secondary Standard Dosimetry Laboratory (SSDL) is a significant achievement for KFSH&RC. It provides calibration of radiation

measuring instruments used within the hospital and extends its calibration services throughout the Kingdom and the Arabian Gulf countries. Sophisticated radiation measuring and experimental work must be done with instruments in order to calibrate them against a standardized source traceable to a recognized primary radiation dosimetry laboratory. This laboratory compares its standards with reference laboratories around the world such as the National Bureau of Standards (NBS), National Physical Laboratory (NPL), and the International Atomic Energy Agency (IAEA). In June 1988, the SSDL was accepted as a member of the joint IAEA/WHO network of Secondary Standard Dosimetry Laboratories.

The Radiation Biology Section (RBS) provides the biological basis of the many uses of radiation in medicine and allied health professions. It is devoted to investigating the actions of radiation on living materials and organisms. The RBS covers the three major clinical radiological specialties: diagnostic radiology, nuclear medicine and radiation therapy, along with the potential detrimental effects on the general population from non-medical uses of different types of radiation. Recently, the RBS started a Biodosimetry project which aims to estimate the radiation doses that were received by public or radiation workers in case of radiation accidents. This project is a team work that requires the concerted collaboration of BPD sections or other KFSH&RC departments (Fig. 2). Currently, the biodosimetry laboratory has been established, and it is a part of a national radiation preparedness emergency plan and it is registered as a first member of IAEA biodosimetry laboratory networks in the region.

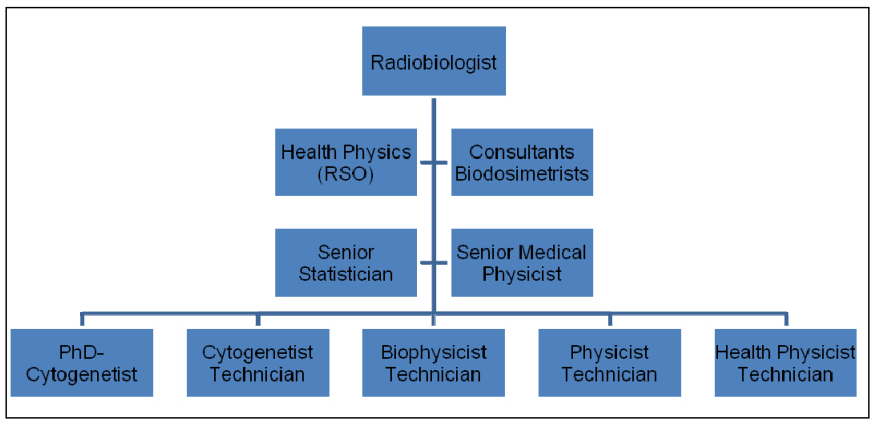

Figure 2: The ideal organization chart for different specialties that involving in biodosimetry project.

The aim of this report is to evaluate the annual radiation monitoring services of Health Physics Section, Secondary Standard Dosimetry Laboratory and Radiation Biology Section for all radiation workers inside and outside KFSH&RC during the period between 2006 and 2012.

2 Materials and methods

The BPD Business Office has been established to stream line the growing of radiation monitoring services. The major roles of Business Office are to receive/send radiation monitoring tools, initiate financial bills, export radiation reports and establish an electronic database. In this report, we presented data that are collected from the Business Office records during the period between 2006 and 2012.

The main techniques used in the Health Physics Section and SSDL to monitor the radiation exposure are the Thermoluminescent Dosimeter (TLD) and survey meters callibration respectively. Furthermore, the Radiation Biology Section used cytogenetic technique to estimate the radiation dose received.

2.1 Health Physics Section

TLD is a type of passive dosimeter which is used for personnel, extremity and environmental monitoring in the field of radiation to ensure that the dose limits have not been exceeded. TLD chips are made from Lithium fluoride elements which are stuck to barcoded cards encapsulated in Teflon [3]. The TLD whole body badges are issued either monthly or quarterly depending on the amount of radiation the person is likely to be exposed. Subsequently, they can be read and analyzed by two state-of-the-art Harshaw 6600 automated TLD systems and a Personnel Dose Information System for electronic storage of dose records, computerized dose calculation and report generation. This service is provided to KFSH&RC staff and also many hospitals, government and private institutions in Saudi Arabia. Moreover, Health Physics Section used NaI gamma/beta detector counting system (Canberra Model 2098) to measure solid suspect sample, while the Genie-2000 system is used to measure liquid sample.

2.2 Secondary Standards Dosimetry Laboratory (SSDL)

The BPD has different types of radiation detecting and measuring instruments used for various types of radiation. They are survey meters for radiation and contamination surveys, counting instruments, radiotherapy dosimeters, direct reading personal dosimeters, TLD system and air monitoring system. The accuracy of the measurement and the relevance of the evaluation done on these measurements depend on the instrument's calibration. The SSDL has six Cs-137 and one Co-60 sources that are housed in a calibration range and whose calibration are all traceable to the National Bureau of Standard (NBS) [4]. In addition, gamma and beta emitting radioactive reference standard sources and reference standard instruments that are existed at the SSDL. Calibration of the reference standard sources and instruments are traceable to primary standard dosimetry laboratories.

2.3 Radiation Biology Section (RBS)

The Radiation Biology Section followed the IAEA protocol to apply the cytogenetic dicentric assay to measure the received radiation doses. When the

energy associated with ionizing radiation is transferred to molecules in the extracted white blood cells, the DNA that embeds the genetic materials is damaged in proportion to the type and amount of energy that is absorbed. In human lymphocytes, this leads to the appearance of structurally abnormal chromosomes when cells attempt to divide following radiation with 0, 0.5, 1, 3 and 5 Gy. Between the different types of chromosomal aberrations induced, dicentric chromosomes appear to be more specific to radiation exposure with a background level practically equal to zero. Hence, the number of dicentrics is quantified by using Metafer 4 system (Metasystem Co.), and compared to a calibration dose-response curve, established in vitro, in order to derive an estimate of possible dose received.

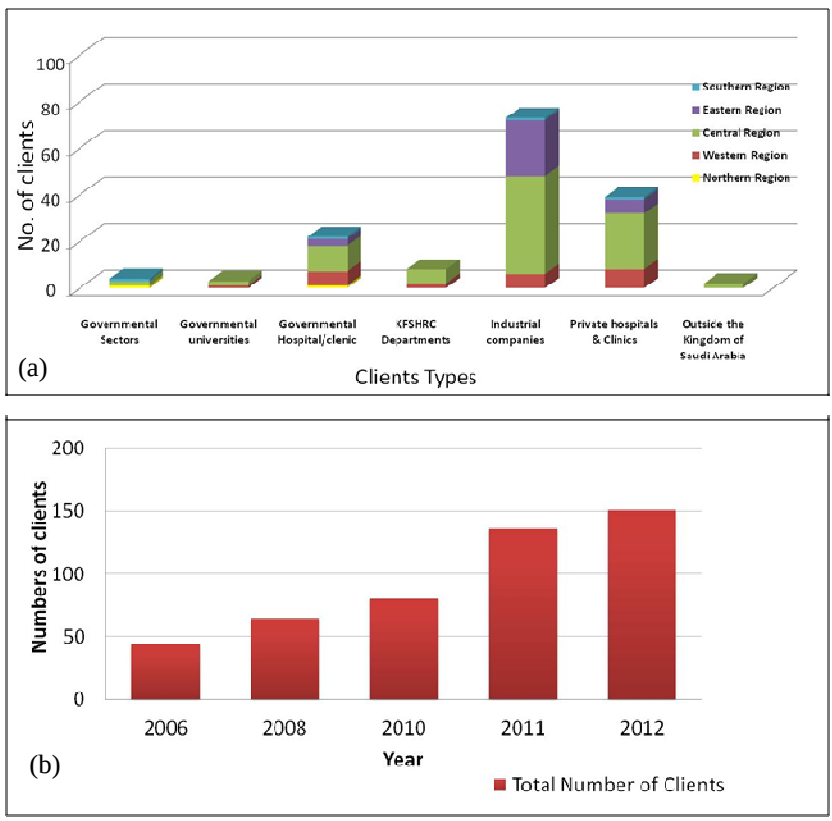

Figure 3: Clients of Biomedical Physics Department: (a) Clients types and Regional Distribution in 2012. (b) Total number of the clients between 2006 and 2012.

3 Results and discussion

In 2012, the BPD served more than 150 clients over all Saudi regions. The highest numbers of clients located in Central region while the Northern and

Southern regions were the lowest. The industrial companies were the main clients between private and governmental initiations (Fig 3a). In contrast, in 2006, the Business Office registered only 44 clients which are less than 3.5-folds in 2012 (Fig. 3b).

During the period between 2006 and 2012, the total number of radiation workers who were monitored increased by more than 500%. As a result, a total of 2,480 TLD chips were scanned monthly or quarterly from 44 local clients in 2006 increased to 19,054 TLD chips from 151 local and regional clients in 2012 (Fig. 4), and it is expected to monitor more than 20500 TLD chips in 2013.

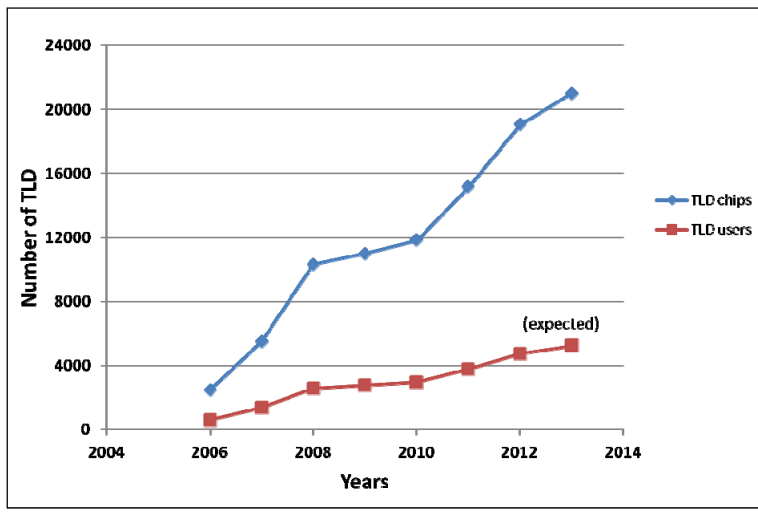

Figure 4: Annual scanned TLD chips and users between 2006 and 2012.

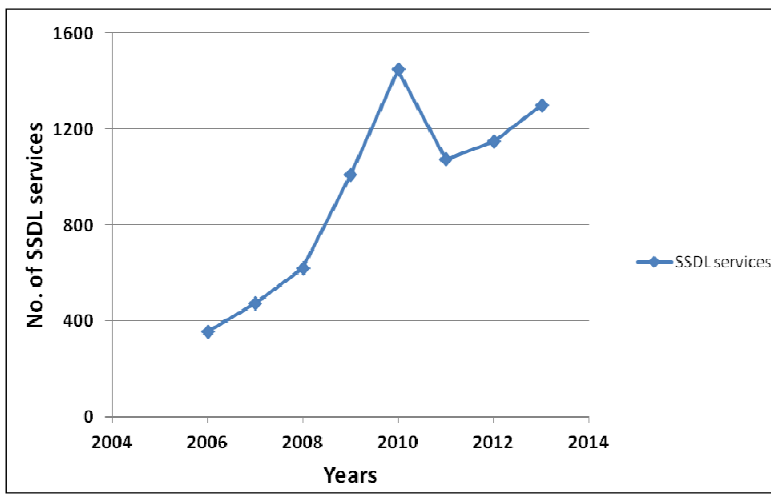

Figure 5: Number of annual SSDL services between 2006 and 2012.

The SSDL has calibrated 1,075 survey meters in 2012 compared to 356 survey meters in 2006 (Fig 5). In addition, swap and radioactive contamination tests for suspect sample as radioactive sources, food, water and milk were increased by 240%.

In 2010, around 500 out of 14440 calibrated survey meters were unseasonal and unexpected package. This justified the decline of the calibration services in 2011 and 2012.

The biodosimetry project is in progress, and it is expected to close in August 2013. However, our data can construct an initial dose calibration curve for cytogenetic biodosimetry in Saudi Arabia by capturing, counting and analysis the dicentric chromosome through Metafer system. Figure 6 shows representative example of metaphase with dicentric chromosomes captured by the Metafer system.

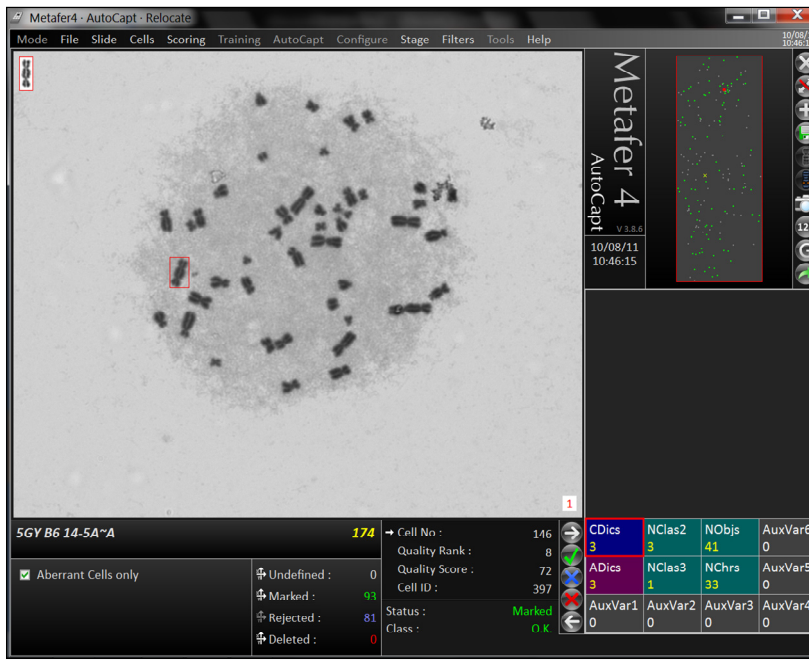

Figure 6: Representative examples of metaphase with dicentric chromosome captured with the Metafer system in our laboratory.

The preliminary results of the calibration dose-response curve are summarized in Table 1 and fitted to a curve curve in figure 7.

This dose response curve is comparable to those described in other population obtained by international laboratories [6]. Accurate calculation of radiation doses received will result in evidence based treatment decisions and better management of valuable emergency resources. In addition to diagnosis of overexposure, the cytogenetic method is standardized by the International Atomic Energy Agency

to provide triage capability for rapid stratification of patients who need more specialized medical care. It can also detect false positives and false negatives exposure particularly in cases of legal allegations.

Table 1: The distribution of dicentric chromosomal aberrations after X-rays irradiation of blood in a Saudi volunteer.

Dose (Gy)	*N. metaphases*	*N. dicentrics*	*D0**	*D1**	*D2**	*D3**	*D4**	*D5**	*Y*
0	1229	11	1218	11	0	0	0	0	0.00895
0.5	1160	22	1138	22	0	0	0	0	0.01897
1	662	52	611	50	1	0	0	0	0.07855
3	502	219	324	142	31	5	0	0	0.43625
5	496	422	271	104	68	34	15	4	0.85081

N. metaphases: number of cells in metaphase assessed. N. dicentrics: total number of dicentrics found in the cells assessed.* Number of metaphases with 0, 1, 2, 3, 4, 5, 6 dicentrics, respectively. Y: yield of dicentrics.

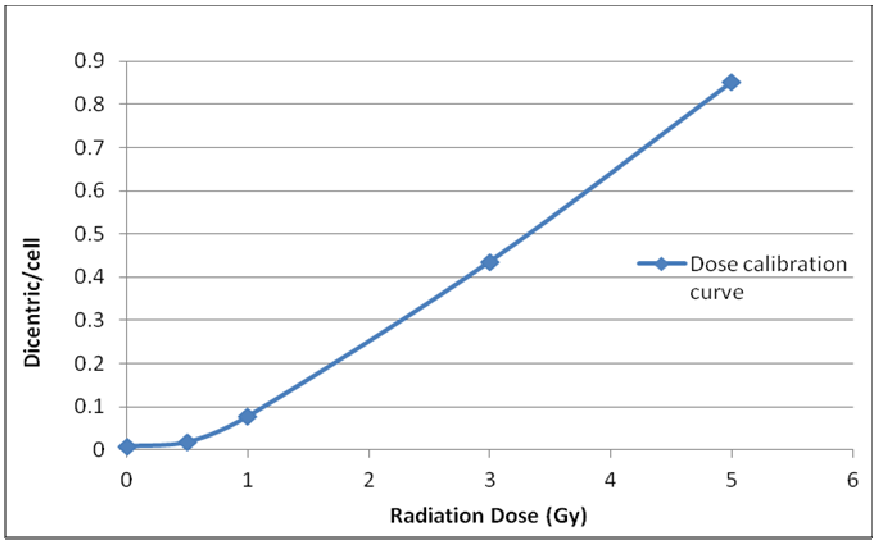

Figure 7: Linear-quadratic standard calibration curve for dicentrics induced in human lymphocytes by X-rays exposure. Data points are the yield of dicentrics per metaphase analyzed.

This report shows the extent of health physics services during the period between 2006 and 2012. Since 2006, the total number of radiation workers in Saudi was exponentially increased which indicates the increase uses of radiation applications in the region. The Biomedical Physics Department at KFSH&RC plays an important role in monitoring of public and radiation workers from

natural and man-made radiation sources in regular, working activity and emergency situation in Saudi Arabia and neighboring countries.

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