Dose Measurements of Relatives, together with Dose Mapping of Common Areas in the Nuclear Medicine Department at KAMC-Jeddah

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Abstract. The enormous hazard that radiation has on public in The Nuclear Medicine Department (NM) has necessitated the Nuclear Regulatory Commission (US-NRC) to set limits for the public doses. Regardless of the consequences of radiation, a small quantity of hospitals such as the Princess Noura Center at King Abdulaziz Medical City in Jeddah in Saudi Arabia does not have an estimated dose measurement for the NM department's areas nor public (patients' relatives). Therefore, the purpose of this study is to measure the doses for patient relatives and dose map the areas in the NM department. The data were measured in the form of Equivalent doses using OSL dosimeters. The methodology of collecting the data for relatives is based on three common procedures which are cardiac, bone, and renal scans. While collecting the data for the areas was fixed in seven positions which are two corridors, two waiting areas, two toilets and an injection room. A comparison between the data and US-NRC regulations were mainly based on the duration and the category. The date for the patient relative's category resulted in 74 samples size while the dose mapping measurements resulted in 7 readings. The public regulation for the US-NRC is 0.002 mSv per hour, while for the area is 1.6 mSv per month. This study showed that the areas and public do not receive dose that exceeds the limits which is recommended by the regulations of US-NRC. Furthermore, several recommendations have been suggested in order to lower the dose for patient relatives and in the common area of the NM department.

Keywords. Nuclear Medicine, Radiation Protection, OSL, Radiology, Dose, EqD.

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1. INTRODUCTION

Nuclear Medicine (NM) is a branch of medical physics that utilizes radioactive materials in order to diagnose treat certain diseases [1]. The radioactive materials are active substances that can be injected, inhaled or ingested to evaluate the body's biological functions [2]. Moreover, these radioactive materials emit electromagnetic waves that can be detected by the gamma camera in order to build the images [1,4]. There are many procedures that are performed in the NM department such as bone, cardiac, and renal scan. NM functions by using radioactive materials that emit high ionizing radiation, which can be harmful to the population like patient relatives in the NM department [1]. Therefore, the Nuclear Regulatory Commission (US-NRC) publicized a restricted regulation for which is 20 mSv per year to ensure establishing the principle of ALARA that stands for (as low as reasonably achievable) that is defined as a safety principle designed to maintain the equivalent dose (EqD) and keep it low as possible [5,6]. However, estimating the amount of ionizing radiation that the relatives of the patient, and areas in the NM receive from patients with radioactive sources is unspecified. Since, they are not provided with dosimeter devices such as OSL (optical stimulation luminescence), which is used to calculate the equivalent dose [7]. The equivalent dose (EqD) is known as a measure of the absorbed dose that a person or an area receives, and the unit for the EqD is milli-sievert [8]. It is important to monitor the dose measurements for relatives and dose mapping for areas that are unsheltered from radioactive patients to facilitate the process of lowering the dose rate. Therefore, many studies have been conducted for the purpose of maintaining the dose rate within the range limit in the NM department. For example, in May 2018, Kinsey Smith performed a research study in Indiana University Purdue University Indianapolis in the United States of America, on calculating the radiation exposure to visitors to NM department waiting areas. The study has been performed in three different hospitals with different NM departments waiting areas. The calculation methodology was obtained by placing two OSL on the walls of each waiting areas' room for three months, at the end of each month the areas' monitors will be sent to be read, and to document the radiation exposure dose rates. Next, the total visitors dose rates for all the three hospitals were compared to the 20 microsievert US-NRC limit regulation dose rate, the study's results calculations were less than the US-NRC limit regulation [1]. Nevertheless, since the result of the study depends on the hospital waiting rooms designs, the population and the methodology used for calculating the radiation exposure it is crucial to be aware of the doses. Hence, the purpose of our research is to calculate the dose measurements of relatives together with dose mapping areas in the NM department at KAMC-Jeddah, by using the OSL dosimeters and compare the readings to the US-NRC regulation limit to confirm that the equivalent doses are within the dose limitation.

The use of radioactive tracers in patients undergoing procedures in NM present a concern on the safety of the patients and their relatives [10]. Therefore, it is crucial to conduct further research in KAMC-Jeddah to measure and estimations of the relatives of the patients, and to reduce their doses with time spent in the NM department. In brief, using radiopharmaceutical source for patients undergoing procedures in NM, might also affect people who are in the same area, such as relatives and workers.

2. METHODOLOGY

The study area is located in Jeddah, Saudi Arabia, King Abdulaziz Medical City (KAMC). The study was conducted in the Nuclear Medicine (NM) department. The research was performed within four months (16 weeks).

A total of 336 adult patients' relatives who were subject to NM procedures were included in this study. [11] This study was conducted in the Nuclear Medicine Department at KAMC-Jeddah, Saudi Arabia. The OSL dosimeters were used to measure the patients' relatives' equivalent doses along with the areas in the NM department. Furthermore, the OSL provides a wide range of sensitivity for detecting the lowest levels of radiation, hence it provides accurate readings. For that reason, it is used internationally by the Radiology Departments' workers as a safety regulation.

A Wilcoxon test is a non-parametric test that is used to show the difference between two statistical data's as shown here between the female and male category as shown in Table 1. The Wilcoxon was used specifically since our data weren't normally disturbed.

The data is analytic cross-sectional. The data was obtained from the OSL in the form of Absorbed dose(D), furthermore these absorbed doses were converted into EqDs which is calculated by Absorbed dose(D)x weighting factor(wR) the unit is millie-sievert. After that the mean of all equivalent doses was analyzed and calculated using the JMP analysis software [12].

3. RESULTS

A group of 74 relatives of patients who were injected with radioactive materials were given the OSL dosimeter device, along with dose mapping 7 areas which are two corridors, female waiting area, female restroom, male waiting area, male restroom, and the injection room at the NM department at KAMC-J.

Table 1 shows that the males were 46 participants who represent 62.2% of the whole 74 sample, while the females were 28 participants who represent 37.8% of the whole 74 sample.

The cardiac represented 39 procedures which is 52.8% from the whole procedures performed, and the number of the bone scan procedures is 29 and it represents 39.1% from the whole percentage of the procedures. Moreover, the number of the renal scan procedures are 6 which is 8.1% from the sum of performed procedures.

Table.1 Frequency distributions obtained from Wilcoxon test that represent the number of the EqDs for each gender.

Characteristic of the Participant and their Percentage (N=74)		
Gender	**Number**	**Percentage**
Male	46	62.2%
Female	28	37.8%

Table.2 Frequency distributions obtained from Wilcoxon test that represent the number of EqDs per hour for public in each type of procedures.

Characteristic of Procedure and their Percentage (N=74)		
Procedure	**Number**	**Percentage**
Cardiac	39	52.8%
Bone Scan	29	39.1%
Renal	6	8.1%

Table 3 shows that the mean for equivalent doses for each participant is 0.116, the standard deviation is 0.046. The standard error resulted in 0.003, and the median was 0.11 while the interquartile range is 0.04. The maximum was 0.4 and the minimum is 0.04.

Figure 1 shows a schematic diagram of the NM department layout and the OSL dosimeters position assigned to the 7 locations to evaluate the dose map. In Figure 2, the EqD for corridor 1 was 0.18 mSv while in the injection room the EqD was 0.24 mSv. Moreover, the male toilet EqD was 0.26 mSv followed by corridor 2 which was 0.4 mSv. The female toilet was 0.41 mSv and the male waiting area was 0.53 mSv, in addition to the female waiting area which was 0.82 mSv.

In Figure 3, the cardiac scan procedure had the highest mean, center, variation, and it is the only category with outliers. Additionally, the bone scan is the second. The comparison between the average of the EqDs per hour of the relatives is 0.04 mSv and the public EqD per one hour for NRC is 0.002 mSv (0.002 > 0.04), showed that the EqDs for the public is 4% of 0.002 mSv NRC limitation per hour. The second comparison was between the NRC regulation for restricted areas per month which is 1.6 mSv and the average of the EqDs of the areas is 0.405 mSv. As a result, (1.600 > 0.405), which shows that areas average EqDs is 40.5% of 1.6 mSv NRC limitation per month.

Table.3 Descriptive statistics of the equivalent dose for each participant.

Characteristics of the Equivalent Dose per Participant (N=74)					
Mean	**Std Dev**	**Median**	**Interquartile Range**	**Max**	**Min**
0.116	0.046	0.11	0.04	0.4	0.04

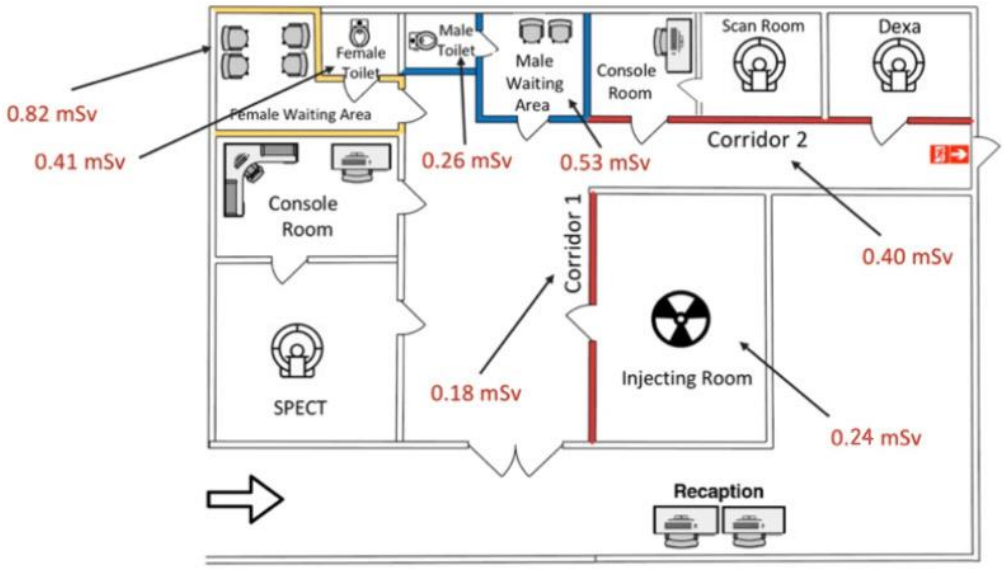

Figure 1 Map of the NM department at KAMC-J

4. DISCUSSION

The radiation exposure at the NM department can be a risk hazard to the relatives of the patients, since they spend 2-4 hours near patients injected with radioactive materials in the waiting areas [13]. Therefore, US-NRC has set regulations for public dose which is 0.002 mSv per hour while for the areas' EqDs 1.6 mSv per month.

This study aims to measure the EqDs for the relatives along with dose mapping seven areas in the NM department at KAMC-J. The null hypothesis (H_o) states that the average public doses per hour is exactly 0.002 mSv per hour. Whereas the alternative hypothesis (H_I) states that the mean of the public EqDs per hour is different from 0.002 mSv per hour. Therefore, based on the t test results, the P-value is less than (P > 0.05). Thus, there is a significant difference suggesting the rejection of the null hypothesis. The results also show that the average of the EqDs for the patient relatives represent 4% from 0.002 mSv per hour as recommended by the US-NRC.

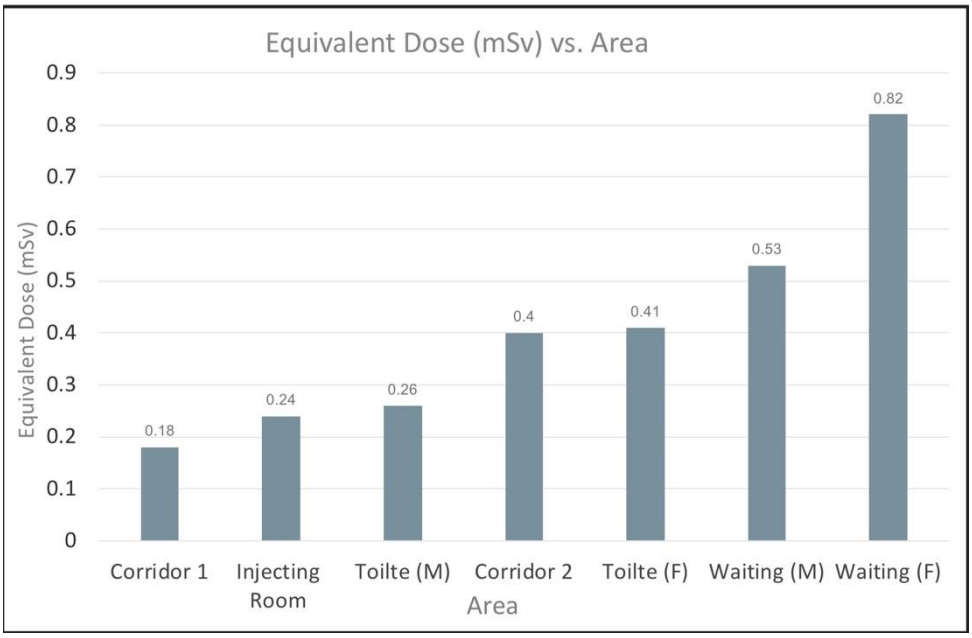

Figure 2 Bar Chart that demonstrates the relation between the EqDs for each area

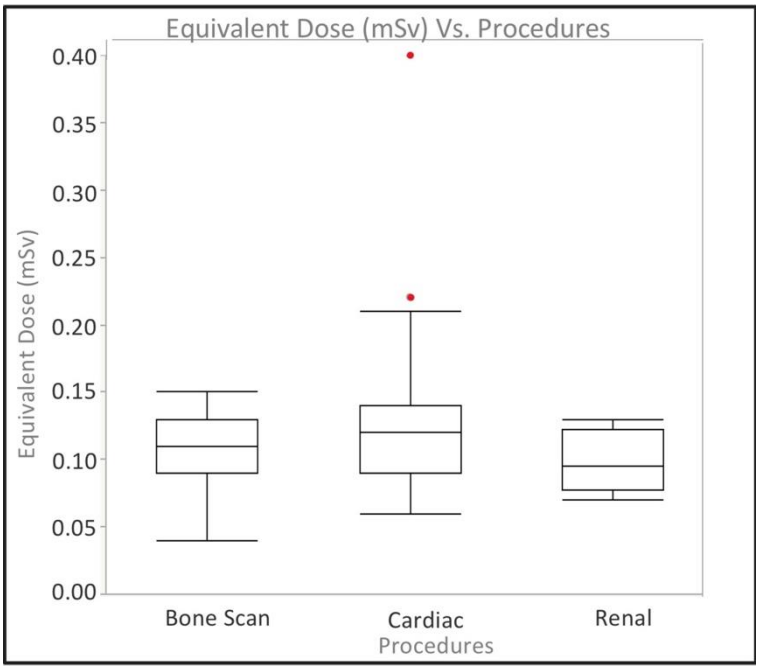

Figure 3 Comparison by the Box Plot graph based on center, variation and outliers of the EqDs in each procedure

Regarding the areas' average radiation exposure, the H_o states that average of the areas' EqDs per month is precisely 1.6 mSv per month. On the other hand, the H_I states that the average of the areas' EqDs per month is different from 1.6 mSv per month. Hence, based on

the t test results, the P-value is less than 0.05 (P> 0.05). Which shows significant difference indicating the rejection of the H_o. In addition, the result shows that the average of the EqDs for the areas is 40.5% from the US-NRC regulation, which is 1.6 mSv per month.

There has been a similar study conducted in the NM departments of three different hospitals in order to compare the measured doses to the US-NRC regulations. In the Kinsey Smith study on Radiation Exposure to Visitors in the NM Department' Waiting Areas, the study sample was conducted by dose mapping the waiting areas only in the NM department. However, this study is mainly focused on the waiting area, which does not show accuracy in estimating the EqDs that the public receive, since relatives are constantly present in different areas in the NM department to accompany patients. Therefore, in our study we dose mapped seven different areas in the NM department. The Kinsey Smith study resulted in an average for the waiting area that is less than the US-NRC regulations limits which shows correspondence with our results for the waiting areas [5]. However, our study's result for the areas is less than Kinsey Smith study's result when compared to the NRC restricted areas limitation.

The limitations in this study were majorly due to shortage of time, the specificity of the data and the poor relative education. The duration of the data collection period was insufficient, since the majority of the patients present to the NM department without relatives. Also, the data were acquired from three specific procedures; however, that were not performed daily. As a result, two months of data collection were not enough to reach the preferred sample size. Also, the unfamiliarity with the insignificant size of the OSL caused the relatives' patients to dismember passing back the dosimeter which resulted in affecting the readings of the data.

A high restriction of radiation protection procedure in the NM department is an essential element. Therefore, it is recommended to separate the patients and relative's waiting areas. In the case of disabled patients, it is recommended that the relatives should leave the NM every few minutes to minimize the continuous exposure to radiation. Finally, it is also recommended to put fixed sign boards on the toilets in the NM department to demonstrate the restrictiveness of this area and that it is only permitted to patients along with guide maps that guide the relatives to the nearest safe restroom.

5. CONCLUSION

The results of this research states, the public and the areas in the Nuclear Medicine Department in Princess Noura Center at King Abdulaziz Medical City do not receive doses that exceeds the regulations of the US-NRC. Thus, the dose measurements show compliance to US-NRC regulations which confirm that the NM department at KAMC-J lies under excellent criteria for high quality protection.

Furthermore, and according to the latest technology of radiation online dose monitoring, which can measure dose and location. It is advisable to make it available in the NM department to monitor radiation dose to the patient relatives of pediatric and elderly patients, and unmonitored workers to improve the quality of radiation protection in NM at KAMC- Jeddah.

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قياسات الجرعة الإشعاعية للأقارب مع رسم خرائط التعرض في المناطق المشتركة في قسم الطب النووي بمدينة الملك عبدالعزيز الطبية بجدة

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الملخص:

تم وضع حدود للجرعات الطاقة الإشعاعية من قبل لجنة التنظيم النووي (US-NRC) في قسم الطب النووي ومع ذلك فإن الجرعة الإشعاعية لمرافقين المرضى، ومناطق الانتظار، و الممرات، وغرفة الحقن، والمرحاض في قسم الطب النووي في مركز الأميرة نورة في مدينة الملك عبد العزيز الطبية في جدة في المملكة العربية السعودية قد تكون تخطت الحد الذي تم السماح به. لذلك، الغرض من هذه الدراسة هو قياس الجرعات لمرفقين المرضى والمناطق داخل قسم الطب النووي.

تم العمل على هذه الورقة البحثية عن طريق معرفة الجرعات باستخدام جهاز قياس يسمى ب الOSL . تعتمد منهجية جمع البيانات الخاصة بالمرافقين على ثلاثة إجراءات وهي فحوصات القلب والعظام والكلى. أثناء جمع البيانات الخاصة بالمناطق تم تثبيت أجهزة ال OSL في سبعة مواضع وهي عبارة عن ممران ، منطقتان انتظار ، مرحاضان وغرفة حقن. استندت المقارنة بين البيانات ولوائح لجنة التنظيم النووي بشكل أساسي على المدة والفئة.

أوضحت البيانات الخاصة بفئة مرافقين المرضي وهي عبارة عن ٧٤ عينة بينما تم قياس جرعات المناطق لمدة ٧ قراءات نظرًا لأنها ثابتة ومتنوعة فقط في المدة.

حددت اللائحة العامة للجنة التنظيم النووي جرعة 0.002 ملي سيفرت في الساعة بالنسبة لمرافقين المرضي ، بينما بالنسبة للمنطقة ١,٦ ملي سيفرت في الشهر. أظهرت هذه الدراسة أن المناطق والعامة لم يتعرضوا لجرعة تتجاوز الحدود التي أوصت بها لوائح لجنة التنظيم النووي. علاوة على ذلك ، تم اقتراح العديد من التوصيات من أجل خفض الجرعة لأقارب المرضى وفي المنطقة المشتركة لقسم الطب النووي.