RESEARCH ARTICLE

SUBJECTIVE EVALUATION OF THE HEALTH IMPACTS OF RADIATION ON OPERATORS OF MEDICAL DEVICES AND ON RADIOACTIVE WASTE COLLECTION WORKERS

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Abstract

Introduction: Healthcare professionals, face various occupational hazards including ionizing radiation, during certain examinations, which can lead to serious health impacts. **Purpose:** This research estimated the impacts of radiation exposure, in the health of medical devices' Operators and radioactive waste collection workers, as well as the knowledge of the employees on various legislative and technical fields. **Material - Method:** The sample consisted of 120 participants, who were chosen through the systematic stratified sampling method. An anonymous questionnaire, consisted of 60 questions was given to the participants. **Results:** The majority of the sample (92.5% N=111), was trained in the operation of the medical equipment, while many (52.5% N=63) were also aware of the legislation on radioactive waste management. However, a high percentage (90.8% N=109), still believes that there is a need to learn more about health and safety in the field of radiation. Thyroid cancer, is considered the most common form of cancer, among the radiological machine Operators (44.4% N=68). There's a statistical significance found, between the development of a disease and the availability of protection means (p=0.012), as well as between the participants' knowledge on legislation and the necessary checks performed on the medical equipment (p=0.05). **Conclusions:** Although employees have the necessary knowledge to manage radiation at the workplace, they are willing to learn more. Finally, most of the workers knew about the use of protection means and had neither a work accident, nor a health problem during their work.

Keywords: ionizing radiation, radioactive waste, health occupations, hospitals, medical devices

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ΕΡΕΥΝΗΤΙΚΗ ΕΡΓΑΣΙΑ

ΥΠΟΚΕΙΜΕΝΙΚΗ ΑΞΙΟΛΟΓΗΣΗ ΤΩΝ ΕΠΙΠΤΩΣΕΩΝ ΤΗΣ ΑΚΤΙΝΟΒΟΛΙΑΣ ΣΤΗΝ ΥΓΕΙΑ ΤΩΝ ΧΕΙΡΙΣΤΩΝ ΙΑΤΡΙΚΩΝ ΣΥΣΚΕΥΩΝ ΚΑΙ ΤΩΝ ΕΡΓΑΖΟΜΕΝΩΝ ΣΤΗ ΣΥΛΛΟΓΗ ΡΑΔΙΕΝΕΡΓΩΝ ΑΠΟΒΛΗΤΩΝ

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Περίληψη

Εισαγωγή: Οι επαγγελματίες υγείας, αντιμετωπίζουν διάφορους επαγγελματικούς κινδύνους, συμπεριλαμβανομένης της ιονίζουσας ακτινοβολίας, κατά τη διάρκεια ορισμένων εξετάσεων, η οποία μπορεί να οδηγήσει σε σοβαρές επιπτώσεις στην υγεία. **Σκοπός:** Η παρούσα έρευνα εκτιμά τις επιπτώσεις της έκθεσης σε ακτινοβολία, στην υγεία των χειριστών ιατρικών συσκευών και των εργαζομένων στη συλλογή ραδιενεργών αποβλήτων, καθώς και τη γνώση των εργαζομένων σε διάφορα νομοθετικά και τεχνικά ζητήματα. **Υλικό - Μέθοδος:** Το δείγμα αποτελούνταν από 120 συμμετέχοντες, οι οποίοι επιλέχθηκαν μέσω συστηματικής στρωματοποιημένης δειγματοληψίας. Ένα ανώνυμο ερωτηματολόγιο, που περιελάβανε 60 ερωτήσεις δόθηκε στους συμμετέχοντες. **Αποτελέσματα:** Η πλειοψηφία του δείγματος (92,5% N=111), εκπαιδεύτηκε στη λειτουργία του ιατρικού εξοπλισμού, ενώ πολλοί (52,5% N=63) γνώριζαν επίσης τη νομοθεσία για τη διαχείριση των ραδιενεργών αποβλήτων. Ωστόσο, ένα υψηλό ποσοστό συμμετεχόντων (90,8% N=109), εξακολουθεί να πιστεύει ότι υπάρχει ανάγκη να μάθουν περισσότερα, περί υγιεινής και ασφάλειας στον τομέα της ακτινοβολίας. Ο καρκίνος του θυρεοειδούς, θεωρείται η πιο κοινή μορφή καρκίνου, μεταξύ των χειριστών ακτινολογικών μηχανημάτων (44,4% N=68). Βρέθηκε επίσης στατιστική σημαντικότητα, μεταξύ της ανάπτυξης ασθενειών στους εργαζομένους και της διαθεσιμότητας σε μέσα ατομικής προστασίας (p=0,012), καθώς και μεταξύ των νομικών γνώσεων των συμμετεχόντων και των απαραίτητων ελέγχων που πραγματοποιούνται στον ιατρικό εξοπλισμό (p=0,05). **Συμπεράσματα:** Αν και οι εργαζόμενοι διαθέτουν τις απαραίτητες γνώσεις για τη διαχείριση της ακτινοβολίας στο περιβάλλον εργασίας τους, είναι πρόθυμοι να μάθουν περισσότερα. Τέλος, οι περισσότεροι εργαζόμενοι γνώριζαν τη χρήση των μέσων ατομικής προστασίας και δεν είχαν ούτε εργατικό ατύχημα, ούτε προβλήματα υγείας κατά τη διάρκεια της εργασίας τους.

Λέξεις - Κλειδιά: Ιοντίζουσα ακτινοβολία, Ραδιενεργά απόβλητα, Επαγγέλματα υγείας, Νοσοκομεία, Ιατρικές συσκευές

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INTRODUCTION

Healthcare sector is a compound field, which includes a variety of professions who face various occupational hazards like biological, chemical, physical and other similar health dangers. These factors set the healthcare workers' health at risk, by causing anxiousness, diseases and injuries. [1,2,3,4]

Ionizing radiation, is considered a physical hazard and is a type of energy, which is released by atoms as electromagnetic waves or particles. [5] Humans are being exposed to natural sources of ionizing radiation, such as the ground, water and vegetation, as well as to human sources, like X-Rays and medical devices. [6]

Ionizing radiation has many beneficial applications, including applications in medicine, industry, agriculture and research fields. As the use of ionizing radiation is increasing, the possibility of hazards' appearance for health is increasing too, unless its use is done in a correct manner. [5]

Radiation is commonly used for diagnostic imaging in healthcare facilities. This includes applications such as X-Rays, magnetic resonance imaging and mammography. However, not all radiation imaging procedures include the use of harmful ionizing radiation, since magnetic resonance imaging and ultrasonic components use magnetic fields and ultrasonic waves. [6]

Besides the patients, healthcare workers are being exposed to major quantity of radiation as well. As technology advances, percutaneous procedures are steadily increasing too. The increased anatomic and technical complexity of such procedures usually demands greater amounts of radiation and more time for imaging, leading to greater exposure of patients and laboratory workers to radiation. Healthcare workers with a steady exposure to radiation are dentists and radiologists, who are specialized doctors using radiation to cure patients.[7]

Exposure to ionizing radiation, may lead to tissue or stochastic reactions (a stochastic outcome represents an outcome in which the possibility of occurrence and not the severity, is defined by the dose). A typical example is the carcinogenesis caused by radiation. [6]

The direct health impacts, like skin burning or acute radiation syndrome, are caused when the radiation dose has outreached the defined levels. Low ionizing radiation doses, may increase the risk of long-term impacts like cancer. [6]

However, when preventive measures for radiation are taken, like tools for radiation protection, leaden walls or aprons, the radiation doses on healthcare workers don't outreach the defined levels for tissue reaction. This means that the main hazards that must be taken into consideration, are the stochastic ones. [8]

It's important that healthcare workers who engage in such procedures, must be aware of radiation exposure and have the necessary tools to protect themselves and the rest of the staff and patients.

PURPOSE

The purpose of this research, is to assess the possibilities of health impacts due to radiation exposure, on operators of medical devices and on radioactive waste collection workers. In addition, this research aims to evaluate the knowledge of the above employees, on the fields of protection against radiation and on radioactive waste management.

MATERIAL – METHOD

The sample of the workers who took part in the research, consisted of men and women of various ages, who pertain to places exposed to radiation and places of radioactive waste gathering. More specifically, a questionnaire was given to doctors, nurses, technicians and other hospital or clinical workers, who use radiation at their work, in order to assess their knowledge levels related to the ionizing radiation, as well as their awareness about the exposure to radiation doses during radiological examinations. For this purpose, the systematic stratified sampling method was used.

The questionnaire was designed to analyze the impacts of radiation as a multidimensional concept, adjusted to the Greek reality as much as possible, in order to investigate the problems of Greek healthcare workers. It also took into consideration the contemporary reality, analyzing its impacts on the workforce of the country.

A total of 120 questionnaires were gathered. The facilities that took part in the research were:

- General "KAT" Hospital of Attica.
- General regional Hospital of Athens "Alexandra".
- Anti-cancer – Oncological Hospital of Athens "Agios Savvas".
- General Hospital of Athens "Hippocrates".
- Company "Apotefrotiras SA".

The questionnaire was anonymous, consisted of 60 questions and the gathered data were used only for the research purposes. The collection of data was carried out during the months of September until November 2017.

RESULTS

Descriptive data

In the present section, the results of the questionnaires will be presented. Table 1, presents the questions and answers that were included in the questionnaire used for the purposes of this research.

To begin with, the mean age of the sample is 42 ± 10 years old, with the younger participant at the age of 19 years old and the oldest participant at the age of 60 years old. The majority of the sample were men (53, 3% N=64), as shown in Table 2, while most of the participants (38.3% N=46), graduated from a superior university (Table 3). Most of the participants (46.6% N=56), were occupied in the radiology departments (Table 4), meaning that the main specialty of the sample was the Technologist - Radiologist (52.5% N=63), followed by the X-ray Operators and Operators of medical equipment (23.3% N=28), as shown in Table 5. The average amount of the years of employment was 11.6 ± 9. The lowest duration of employment was 6 months, while the highest was 35 years. Moreover, the 55.8% (N=67) of the participants stated that they work in shifts. Meanwhile, the 43.3% (N=52) do not work in shifts and a 0.8% (N=1) did not answer.

In addition, the percentage of participants who stated that their knowledge is sufficient in terms of radiation management at hospitals was high (50.8% N=61). On the other hand, the percentage of those who answered negatively was lower (39.2% N=47), while the 10% (N=12) did not answer. However, those participants who stated that their knowledge is not enough, added that such knowledge can be obtained through the working experience (19.2% N=23), as well as through courses attended at Vocational Training Centers or through other faculties (8.3% N=10). At all circumstances, the majority of the participants (90.8% N=109) believe that there is a need to learn more about health and safety in the field of radiation. The percentage of the sample (9.2% N=11) that answered negatively was low.

Furthermore, the majority of the sample (92.5% N=111) stated that they have been trained in the operation of the medical machines that they use, while the percentage of those who answered partially or not was 4.2% (N=5) and a 3.3% (N=4) did not answer. A positive response was also given by a high percentage (91.7% N=110) of the sample, concerning the knowledge on radiation protection by employees, while only 5.8% (N=7) answered negatively and a 2.5% (N=3) did not answer. In addition, most of the participants (52.5% N=63) stated that they are aware of the legislation on radioactive waste, as well as the ways of its collection and deactivation. However, the 43.3% (N=52) of the sample answered negatively to this question and the 4.2% (N=5) did not respond. A positive answer was finally given by a high percentage (45% N=54) of the sample, regarding the implementation of the law, while the 11.7% (N=14) answered negatively and the 7.5% (N=9) stated that the law is implemented

partially. The percentage of the 35.8% (N=43) who did not answer is also important.

Moreover, many of the participants (75.8% N=91) stated that they did not develop any disease during their work, in contrast to the 20% (N=24) of the participants who replied positively, while the 4.2% (N=5) did not respond. Among the positive answers, the average time of a disease development was 10.9 ± 6.3 years. The majority of the answers (23.3% N=53) also stated that the most important Personal Protective Equipment (PPE) is the lead apron, while the 17.2% (N=39) mentioned the radioprotection equipment in general, without any reference to a specific equipment. Furthermore, the 16.3% (N=37) of the answers, chose the shielding walls and areas made of lead, the 15.9% (N=36) preferred the spatial and time distance from a source of radiation, while the 15% (N=34) chose a protective thyroid collar. In addition, the 3.5% (N=8) of the answers chose the use of special dosimeter, the 3.1% (N=7) preferred the use of protective glasses, the 2.6% (N=6) stated that the use of a coverall is the most important PPE, while the 1.8% (N=4) chose the use of protective diaphragms and the 1.3% (N=3) preferred the use of a mask. It is worth mentioning that many of the participants gave more than one answers, since they considered a combination of PPE as equally important.

Also, some participants mentioned various other techniques and measures, such as the radioprotection of the patients' genitals, examination with fast moves, employees' training, control by a physicist or by the National Science Research Center "Dimokritos", regular checks for leaks, as well as the control of radioactive contamination with the use of radiation meters and dosimeters. Moreover, regular briefings, use of high-tech machines, minimal use of radioactive elements in imaging, limitation of the dose and field of radiation, as well as compliance with the manufacturer's specifications, regular inspections and ISO maintenance of the devices, were also suggested by the participants. It is interesting that many participants believe (77.5% N=93), that the professional risk increases, due to the non-cooperation of the bedridden patients, while the 17.5% (N=21) did not agree with the above and the 5% (N=6) gave no answer.

Concerning the availability of the means of PPE for the employees, the percentage of the participants who stated that there are appropriate means of protection available for the workers was high (53.3% N=64), mentioning apron, thyroid collar and lead protection on the walls, as seen in Table 6. Also the 20.8% (N=25) chose the use of a protective apron and lead protection on the walls. Also, the 74.2% (N=89) of the sample stated that the radiation protection means are observed at a satisfying level, while the 22.5% (N=27) of the sample considered their compliance on the use of PPE as partial and the rest of the 3.3% (N=4) did not answer.

A positive answer was also given by a high percentage of the sample (91.7% N=110), regarding the fact that there is a professional dosimeter provided at work, in order to estimate the dose of radiation received by the employees. The average value of radiation exposure of employees per day was 8.5 hours. However, the 7.5% (N=9) of the participants replied negatively, while the rest of the 0.8% (N=1) did not answer. In addition, asking the participants about whether there is a radiation counter installed on the waste trucks, half of the sample (50% N=60) responded positively, while the other 25% (N=30) said "no" and the other 25% (N=30) did not respond.

Moreover, the 80.8% (N=97) of the sample answered positively, regarding the fact that the radiological equipment is being maintained, while the other 11.7% (N=14) answered negatively and the rest of the 7.5% (N=9) did not respond. As for the question about whether the portable or fixed medical equipment is being checked, the 74.2% (N=89) answered positively, while the 18.3% (N=22) replied negatively and the rest of the 7.5% (N=9) did not respond. When the participants were also asked how often the equipment is maintained, the majority (15% N=18) answered that the

maintenance is done every 3 months, while the 12.5% (N=15) answered every 6 months, the 4.2% (N=5) answered every 4 months and the 6.7% (N=8) stated that the maintenance is done according to the manufacturers' specifications. However, the percentage of the participants who did not answer was high (61.7% N=74). Finally, the 52.5% (N=63) of the sample stated that the necessary checks are being performed in their workplace, by the staff of the National Science Research Center "Dimokritos", the 35% (N=42) answered that they do not know, while the 12.5% (N=15) replied negatively.

Furthermore, the percentage of the participants who stated that they know how much time the scattering rays remain in the X-ray room was high (52.5% N=63), while the 36.7% (N=44) did not know and the rest of the 10.8% (N=13) did not answer. As for the time that the scattering rays remain in the X-ray room, the 15.8% (N=19) of the sample answered that the radiation remains for seconds after the examination, while the 10% (N=12) stated that the radiation remains for few minutes. However, the 8.3% (N=10) of the participants replied that the scattering rays do not remain at all after the examination and the 6.7% (N=8) answered that the radiation is emitted only during the examination. Finally, the majority of the sample (59.2% N=71) did not answer to this question.

However, a positive answer was given by the highest percentage of 90.8% (N=109) of the sample, regarding whether they believe that the exposure to radiation during pregnancy causes problems on the fetus. Only 2.5% (N=3) of the participants answered negatively, while the 6.7% (N=8) did not respond. In addition, the 84.2% (N=101) of the participants believe that the exposure to radiation causes problems on DNA, while only a 10% (N=12) answered negatively and a 5.8% (N=7) of the sample gave no answer. Also, the 80.8% (N=97) of the participants knew that the long-term exposure to radiation has a cumulative effect, increasing the risk of Down syndrome and spontaneous abortions, due to chromosomal abnormalities. However, the 15% (N=18) of the sample replied negatively and the rest of the 4.2% (N=5) did not respond.

Concerning the most common forms of cancer developed on radiological machine Operators, the 44.4% (N=68) of the answers referred to thyroid cancer, leukemia was mentioned at the 41.8% (N=64) of the answers, while lymphoma (9.8% N=15) and genital cancer (3.9 N=6) were also mentioned, as shown in Table 7. The participants also reported various forms of cancer on organs or body areas such as the uterus, prostate, lungs, intestines, gastrointestinal tract, skin, brain, colon, breast, thorax and pancreas. It is worth mentioning that many of the participants gave more than one answers, since they considered many forms of cancer as equally common.

Moreover, the majority of the participants (85% N=102) stated that the contaminated radioactive waste is collected in special areas. However, the 6.7% (N=8) answered negatively, while the 8.3% (N=10) did not respond. The 20% (N=24) of the sample also stated that the radioactivity of waste decreases, according to the half-life of each radioactive waste, the 5% (N=6) answered that it depends on the type of doubling time, while the 17.5% (N=21) answered that it can take up to 3 days. Finally, the 2.5% (N=3) of the participants stated that it can take days for the radioactivity decrease of the waste, the 1.7% (N=2) believe that this can take years, while the majority of the sample (53.3% N=64) gave no answer, which is also important.

Correlations

There's a statistical significance found, in the difference between the development of a disease and the availability of protection means (p=0.012). As shown in Table 8, the 65.5% of the sample who stated that they hadn't develop any disease during their employment, also mentioned that there are all the appropriate means of protection available at their workplace, such as aprons, lead protection and thyroid collars. In contrast, the

34.8% of the participants who had developed a disease during their employment, also stated that there are all the aforementioned means of protection available at their working environment.

Another statistical significance was found, in the difference between the participants' knowledge of legislation and the necessary checks performed on the medical equipment (p=0.05). More specifically, Table 9 shows that the 86.2% of the participants who stated that the necessary functional checks are regularly performed, on either portable or fixed medical devices, answered also that they are aware of the legislation on radioactive waste management. In contrast, a lower percentage of 70.8% of the participants, stated that they are unaware of the legislation.

DISCUSSION

This research estimated the impacts of radiation exposure, in the health of medical devices' Operators and radioactive waste collection workers. In addition, the knowledge and perception of the employees on various legislative and technical fields, as well as the risk assessment during a radiological examination, have also been evaluated.

According to the participants' answers, the majority stated that their knowledge concerning the radiation management in the hospital is sufficient. However, those whose knowledge isn't sufficient, stated that such knowledge can be obtained through the working experience, as well as through courses attended at Vocational Training Centers, or through other faculties. Indicatively, a study conducted on medical students, showed that the majority of students had limited knowledge about different aspects of radiation management. [9]

Moreover, the sample's majority answered positively, in regards to whether the working conditions including the desktop's height, the lighting (natural or artificial) and the air quality are satisfactory. As for the temperature and humidity, the sample stated that these are in a normal range at all seasons. A similar study conducted by Juibari et al. [10], proved that the ergonomics in such workplaces is very important. Also, a study from Ghasemi et al. [11], stated that any workplace that hasn't been designed based on the ergonomic principles, leads to a significant reduction of work efficiency.

Furthermore, the sample's majority stated that they had been trained on the operation and handling of the medical equipment they use at work. Usually, the training was undertaken by an older colleague, or done through studying the manual's instructions for use. It is really important the fact that the sample's majority, never faced any problem with the medical devices' operation.

In addition, the sample's majority neither had an accident at work, nor any health problem or disease prior to, or during their occupation. However, these results don't agree with the study of Juibari et al. [10], where it was shown that the 83% of healthcare professionals were being exposed to mild work difficulties and injuries at work, while the 4.6% were being exposed to serious injuries. Moreover, the study of Shimizu et al. [12], showed that working in intensive care units (ICUs), implies the exposure to moderate physical hazards.

It is also encouraging, that the participants knew about the compliance on the means of protection against radiation and the fact that these were used at a satisfactory rate. Regarding the appropriate means of protection against radiation for the workers, the use of aprons, thyroid collars and lead protection on walls, were mentioned by the participants. The research of Shimizu et al. [12], showed in contrast that the doctors and nurses in the surgical unit, didn't follow precise instructions for self protection against exposure to radiation during their work.

Moreover, the majority of the participants on this research, stated that there is a professional dosimeter in their working area, in order to estimate the dose of radiation received by the employees. It is important that the radiation doses received by the working staff, must

be measured and evaluated, according to parameters related to the total radiation load. This protection measure is mentioned in many studies abroad, where the use of a thermocouple dosimeter, is the most appropriate method for performing measurements on personal dosimeters. [13, 14, 15, 16]

Also, a high percentage of the sample on this research, stated that the radiological equipment is maintained approximately every 3 or 6 months. Most of the employees, knew how long the scattering rays remain in the X-ray laboratory, answering "seconds or minutes". On the other hand, the research of Rassin et al. [17], showed that more than 80% of the medical staff, were unaware of the amount of environmental radiation, that was equivalent to an X-ray or Computed Tomography.
In addition, a high percentage of the participants answered positively, about whether the exposure to radiation during pregnancy, causes problems in the fetus, as well as DNA problems, increasing the risk of Down syndrome and spontaneous abortions, due to chromosomal abnormalities. Similar researches, mentioned as well that the ionizing radiation, can cause damages on the DNA, related to neoplastic transformation. [18, 19]

Finally, the most common types of cancer among the radiological device Operators, as reported by the sample, are thyroid cancer, leukemia and lymphoma. These answers, come in agreement with the results of the research conducted by Boonsirikamchai et al. ,[20] where it was proven that the most common types of cancer among Radiologists, is leukemia in males and brain and thyroid cancer in female workers. Furthermore, in the research of Rassin *et al.* [17], the majority of the doctors and nurses, reported that they were aware of the fact that the ionizing radiation, could lead to cancer and genetic alterations.

CONCLUSIONS

According to the results of this research, most of the employees work in the radiology department, meaning that the specialty of the Technologist - Radiologist was the main of the sample, with an average employment of 11.6 ± 9 years and working in morning hours.

Furthermore, employees consider that they have the necessary knowledge to manage radiation within the hospital and that they are willing to expand their knowledge through courses attended at Vocational Training Centers, or through other faculties. They also consider that there is the necessity of learning more, about health and safety issues in the field of radioactivity.

Regarding the ergonomics and the prevailing conditions in their workplace, the employees expressed their satisfaction. In particular, they replied that their desktop is satisfactory, with a satisfactory height. In addition, the lighting and air quality are satisfactory as well, while the temperature, ventilation and humidity are in normal levels, both in winter and summer.

In terms of training, the participants stated that they had been trained, on the operation and handling of the medical devices, by an older colleague and that they never faced any problem with the operation of the medical equipment.

Regarding their workload, they reported that monotony and mental fatigue are in normal levels, in contrast to repeatability and physical fatigue, which are in high levels. As for the relationships with their chiefs and colleagues, these are good, while conflicts are indifferent.
In addition, concerning the settlement, it was observed from the participants' answers, that there is a proper settlement in terms of hygiene and safety, as well as in the way of the work implementation. Also, the current health and safety measures are satisfactory, establishing appropriate breaks or replacements when the workload is very high. However, the staff stated that it feels anxious during their work.

Significant were the results, concerning that the employees had neither a work accident, nor a health problem during their work. The majority of the workers, knew about the compliance on the use of radiation protection means. Aprons, thyroid collars and lead

protection on the walls, were mentioned as important means of protection against radiation exposure, while their use by the staff was at a satisfactory level as well. Moreover, the employees mentioned that there is a professional dosimeter and a radiation counter in the working area, in order to assess the dose of radiation received by the workers, as well as that the contaminated radioactive waste is collected in special areas. According to the answers of the participants, the radioactivity decrease depends on the half life of each radioactive waste. Also, a high percentage of the participants, stated that they are aware of the legislation on radioactive waste management and that the law is being implemented.

As for the radiological equipment, the participants stated that it is usually maintained every 3 to 6 months, while the necessary functional checks of the medical devices, either portable or fixed ones, are performed on a regular basis. In addition, the majority of the sample reported that the scattering rays remain in the X-ray laboratory, for seconds or minutes after the examination. Also, the sample responded positively, about whether the exposure to radiation during pregnancy causes problems on the fetus and/or DNA problems. The participants also stated that the long-term exposure to radiation has a cumulative effect, increasing the risk of Down syndrome and spontaneous abortions, due to chromosomal abnormalities. Finally, thyroid cancer, leukemia and lymphoma, have also been reported as the most common cancers, among the radiological device Operators.

ΒΙΒΛΙΟΓΡΑΦΙΑ

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APPENDIX

Table1: The questions and answers that were included in the questionnaire used for the purposes of this research.

Questions	**Answers**
1. What is your gender?	Male Female
2. What is your marital status?	Single Engaged Widowed Divorced
3. What is your educational level?	Primary school Secondary school High school Technical / Professional school Superior University Supreme University
4. Do you believe that your knowledge is sufficient to manage radiation within the hospital?	Yes No
5. If not, how do you believe that your knowledge can be strengthened?	Experience Vocational Training Centers Other faculties
6. At what department / service do you belong?	Radiology Nuclear / Medicine CT and MRI scanner Incinerator Other
7. What is you specialty?	Technologist - Radiologist Doctor X-ray Operator and Operator of medical equipment Nurse Other
8. Do you work outdoors?	Yes No
9. Do you work in shifts?	Yes No
10. What are your normal working hours?	Morning hours Midday hours Nighttime hours All of the above
11. Is your workplace surface area satisfactory?	Yes Partially No
12. Is your desktop's height satisfactory?	Yes Partially No
13. Is there satisfactory lighting (natural or artificial)?	Yes Partially No
14. Is the air quality satisfactory?	Yes Partially No
15. How's the temperature during winter at your workplace?	High Normal Low
16. How's the temperature during summer at your workplace?	High Normal Low

Questions	**Answers**		
17. How's the ventilation at your workplace?	High	Normal	Low
18. How's the humidity during winter at your workplace?	High	Normal	Low
19. How's the humidity during summer at your workplace?	High	Normal	Low
20. Have you been trained in the operation of the equipment you use?	Yes	No	
21. If yes, how?	By an older colleague	By reading the device's manual	All of the above
22. Did you face any problems during the operation of a medical device?	Yes	No	
23. If yes, what sort of problems?	Damages	Old technology	
24. Monotony during work is:	High	Normal	Low
25. Repeatability during work is:	High	Normal	Low
26. Mental fatigue during work is:	High	Normal	Low
27. Physical fatigue during work is:	High	Normal	Low
28. How is your relationship with your bosses?	Good	Indifferent	
29. How is your relationship with your colleagues?	Good	Indifferent	
30. What were the causes of conflicts that you remember?	Good	Indifferent	
31. Do you think that there is a proper procedure (in terms of hygiene and safety) in the way of implementing your work?	Yes	No	
32. Are you provided by appropriate breaks when the workload is high?	Yes	No	

Questions	Answers					
33. Do you consider the current health and safety measures satisfactory?	Yes			No		
34. Do you feel anxious during work?	Yes			No		
35. Have you ever been involved in a work accident?	Yes			No		
36. What health problems existed before working in this department?	Thyroid disease	Vision problems	Cancer	None		
37. Is there a heredity history in the above diseases?	Yes			No		
38. Did you have any disease development during your employment?	Yes			No		
39. Do you have any knowledge on the use of protection means against radiation?	Yes			No		
40. Which is the most important personal protective equipment on your opinion?	Apron	Lead protection on walls	Thyroid collar	Protective glasses	Dosimeter	All of the above
41. Is there compliance on the radiation protective means?	Satisfying			Partially		
42. Which of the means of protection against radiation are available at work?	Apron	Lead protection on walls	Apron and thyroid collar	Apron and lead protection	Thyroid collar and lead protection	All of the above
43. Is there a professional radiation dosimeter available at the working area?	Yes			No		
44. Is there a radiation counter installed on the waste trucks?	Yes			No		
45. Is the radiological equipment being maintained?	Yes			No		
46. If yes, how often?	Every 3 months	Every 4 months	Every 6 months	According to the manufacturer's specifications		

Questions	Answers				
47. Do you know how long the scattering rays remain after the examination?	Yes		No		
48. If yes, how long?	Seconds	A few minutes	Not at all	As long as the examination	
49. Do you believe that the exposure to radiation during pregnancy causes problems on the fetus?	Yes		No		
50. Do you believe that there is a need to learn more things about health and safety in the field of radiation?	Yes		No		
51. Do you believe that the exposure to radiation causes DNA problems?	Yes		No		
52. Are you familiar with the legislation concerning radiation waste management?	Yes		No		
53. Do you believe that the law is being implemented?	Yes		No		
54. Which do you think are the most common forms of cancer on Radiologists?	Thyroid cancer	Leukemia	Lymphoma	Genital cancer	
55. Do you believe that the professional risk increases due to the non-cooperation of the bedridden patients?	Yes		No		
56. Are the necessary functional checks on the medical devices (portable or fixed ones) being performed?	Yes		No		
57. Is the radiological waste being gathered in special areas?	Yes		No		
58. If yes, do you know in how long the radiation is reduced?	Up to 3 days	According to the half life of each radioactive waste	Depends on the type of doubling time	Days	Years

Questions	Answers		
59. Are the necessary checks being performed by the National Science Research Center "Dimokritos" at your work-place?	Yes	No	I don't know
60. Did you know that the long-term exposure to radiation has a cumulative effect, increasing the risk of Down syndrome and spontaneous abortions, due to chromosomal abnormalities?	Yes	No	

Table 2: Gender percentages of the participants.

Gender	Number	Percentage
Male	64	53.3%
Female	51	42.5%
Blank	5	4.2%
Total	120	100%

Table 3: Educational background percentages among the participants.

Education	Number	Percentage
Primary school	1	0.8%
Secondary school	4	3.3%
High – school	12	10%
Technical / Professional school	27	22.5%
Superior University	46	38.3%
Supreme University	29	24.2%
Blank	1	0.8%
Total	120	100%

Table 4: Percentages of departments or services of occupation among the participants.

Department - Service	**Number**	**Percentage**
Radiology	56	46.6%
Nuclear Medicine	23	19.2%
CT and MRI Scanner	14	11.7%
Incinerator	12	10%
Other	11	9.2%
Blank	4	3.3%
Total	120	100%

Table 5: Percentages of specialties of the participants.

Specialty	**Number**	**Percentage**
Radiology Technician	63	52.5%
Doctor	5	4.2%
X-ray Operator and Operator of medical equipment	28	23.3%
Nurse	6	5%
Other	10	8.3%
Blank	8	6.7%
Total	120	100%

Table 6: Percentages of the suitable means of protection available at the participants' working environment.

Available means of protection	**Number**	**Percentage**
Apron	10	8.3%
Lead protection on the walls	7	5.8%
Apron and thyroid collar	2	1.7%
Apron and lead protection	25	20.8%
Thyroid collar and lead	2	1.7%
All of the above	64	53.3%
Blank	10	8.3%
Total	120	100%

Table 7: Percentages of answers concerning the most common forms of cancer, developed on radiological machine Operators.

Most common forms of cancer	**Number**	**Percentage**
Thyroid cancer	68	44.4%
Leukemia	64	41.8%
Lymphoma	15	9.8%
Genital cancer	6	3.9%
Total	153	100%

Table 8: Disease occurrence during the employment, in relation to the availability of the appropriate means of protection for the employees.

Disease occurrence during employment		**Available and appropriate means of protection for the employees**					
		Apron	**Lead protection in examination areas**	**Apron and thyroid collar**	**Apron and lead protection**	**Thyroid collar and lead protection**	**All of the above**
Yes	**Number**	2	1	1	9	2	8
	Percentage	8.7%	4.3%	4.3.%	39.1%	8.7%	34.8%
No	**Number**	6	6	1	16	0	55
	Percentage	7.1%	7.1%	1.2%	19%	0%	65.5%

Table 9: The participants' knowledge of legislation on radioactive waste management, in relation to the performance of the necessary checks on portable or fixed medical equipment.

Participants' Knowledge of legislation on radioactive waste management		**Performance of the necessary checks on portable or fixed medical equipment**	
		Yes	**No**
Yes	**Number**	50	8
	Percentage	86.2%	13.8%
No	**Number**	34	14
	Percentage	70.8%	29.2%