(ISSN Online: 3006-1113) Full Paper

Libyan Journal of Medical and Applied Sciences

Journal homepage: https://ljmas.com/index.php/journal/index

RESEARCH ARTICLE

Estimation of Radiation-Induced Cancer Risk and Mortality from Digital Radiography in Selected Northeastern Libyan Hospitals

Jemila Mussa Ali [a], Enas Gamil Saada [b]

[a,b] *Department of Physics, Faculty of Science, Omar Al-Mukhtar University, El-Beida, Libya.*

Article Information

Article history:
Received on:8/Jan/2026
Revised on: 23/Fab/2026
Accepted on:1/Mar/2026
Published on:17/Mar/2026

Keywords:
Digital Radiography,
Cancer Risk,
Chest PA,
Cervical spine LAT,
Lumbar spine AP

Abstract

Diagnostic X-ray imaging is a fundamental modality for the clinical identification of patient health issues; however, it inherently involves increased exposure to ionizing radiation, which contributes to a patient's cumulative radiation dose. The primary aim of this study was to calculate cancer risk in digital diagnostic imaging using X-rays across three hospitals in northeast Libya. Specifically, the study calculated incidence and mortality cancer risks for adult patients undergoing three common radiographic examinations: chest PA, cervical spine LAT, and lumbar spine AP. A dataset comprising 272 adult male and female patients in the three identified hospitals, divided as follows: the first hospital (Hospital 1) had 99 patients, the second hospital (Hospital 2) had 91 patients, and the third hospital (Hospital 3) had 82 patients categorized into three age groups (20-40, 41-60, and 61-80 years), was analyzed to evaluate radiation dose using the CALDose_X software packages. The results showed that hospitalized patients in Hospital 3 showed a lower risk of cancer for all types of tests compared to patients in Hospitals 1 and 2. The results underscore the necessity for enhanced awareness of radiation-associated risks and the implementation of effective mitigation strategies.

1. Introduction

In diagnostic radiology, X-rays are used, which are electromagnetic waves belonging to the high-energy part of the electromagnetic spectrum; these waves have enough energy (in the medical imaging range) to ionize the patient's body atoms and liberate the electrons. Damage to the tissue brought on by this process may result in cell mutations or apoptosis. The interaction of ionizing radiation with biological systems, invariably induces biological effects. The nature and severity of these effects are contingent upon some factors, such as the absorbed dose, the dose rate, and the radio-sensitivity of the exposed organs [1,2].

In cases of medical exposure, it is legally required to optimize the dose of radiation, since exposure to ionizing radiation is a risk factor for cancer. The higher the dose of radiation, the greater the chance of tissue damage; this biological damage is referred to as a stochastic effect [3]. The ICRP categorized radiation impacts that cause tissue reactions as deterministic effects in Publication 60 (ICRP, 1991b) and referred to radiation-induced cancer and genetic conditions as stochastic effects, where the committee divided the health effects of radiation into two general categories: deterministic effects and stochastic effects [4]. The ICRP suggests that the average absorbed dose in a tissue or organ is the proper dosimetric indication for stochastic effects [5].

According to data from the Radiation Effects Research Foundation, about 90-95% of cancer cases are due to genetic mutations caused by environmental factors and lifestyle, while 5–10% are caused by radiation exposure [6,7, 8]. The objective of digital radiography is to produce high-quality diagnostic images while minimizing the absorbed dose to the patient. This is achieved by carefully selecting exposure factors, which include Tube Voltage (kVp), Tube Current (mAs) and focus to detector distance (FDD) [9,10].

DOI: https://doi.org/10.64943/ljmas.2026.04116

In modern practice, especially within high-dose diagnostic environments, radiation risk coefficients are essential tools for quantifying potential cancer incidence [11]. It is based on the linear no-threshold (LNT) model which assumes that any dose, no matter how small, carries a risk [12, 13, 14]. This study utilizes these coefficients to evaluate the mortality and morbidity risks associated with common digital radiography examinations in selected hospitals across northeastern Libya.

2. Materials and Methods

This research is a cross-sectional comparative dose assessment study conducted across three hospitals in northeast Libya. It utilizes an analysis of exposure parameters and prospective X-ray machine output measurements to quantify and compare potential cancer risks associated with digital radiography.

2.1. Radiology departments

The study encompassed three digital X-ray machines in three different radiology departments (Hospital 1, Hospital 2, and Hospital 3), respectively, that are substantially similar in tube specifications, as shown in Table 1, and we tried to have minor differences not affect measurements or results. We noticed that the targeted radiology departments lack quality assurance and quality control protocols.

Table 1: The X-Ray machines specifications.

Hospital	Type	Max Kv	Max mA	Total filtration mm Al	Date of installation
Hospital1	Digital Radiography	150	630	2.5	June 2015
Hospital2	Digital Radiography	150	1000	2.5	January 2019
Hospital3	Digital Radiography	150	1000	2.5	April 2019

2.2. Patient information

The study targeted adult patients aged between 20 and 80 years, of both sexes (male and female); attending the three targeted hospitals over a 4-month period. The total number of patients was 272, divided as follows: the first hospital (Hospital 1) had 99 patients, the second hospital (Hospital2) had 91 patients, and the third hospital (Hospital 3) had 82 patients. Categorized the patient's information into three age groups: from 20 to 40, from 41 to 60, and from 61 to 80 years. Table 2. displays the number of patients by age group and type of examination per X-ray department. Patient data (sex, age) was taken for three different types of examinations most frequently in radiography: chest PA (postero-anterior X-ray projection), cervical spine LAT (lateral X-ray projection), and lumbar spine AP (anterio-posterior X-ray projection).

Table 2: The Patients' Statistics.

Hospital	Examination type	Number of patients by age group			
		20-40 y	41-60 y	61-80 y	Total
Hospital 1	Chest PA	13	16	16	45
	Cervical spine LAT	11	10	8	29
	Lumbar spine AP	7	9	9	25
	Total	31	35	33	99
Hospital 2	Chest PA	9	17	16	42
	Cervical spine LAT	8	7	6	21
	Lumbar spine AP	11	9	8	28
	Total	28	33	30	91
Hospital 3	Chest PA	10	11	10	31
	Cervical spine LAT	10	11	8	29
	Lumbar spine AP	10	6	6	22
	Total	30	28	24	82

2.3. Mean exposure parameters data

In order for the cancer risk to be estimated, exposure factors (operation parameters) were recorded for all patients. These include tube voltage (kVp), tube current (milliampere second mAs), and X-ray focus-to-detector distance (FDD in cm).

Table 3: Mean exposure parameter used in hospital 1.

Examination type	Age (y)	Mean ± SD		
		kV	mAs	FDD (cm)
ChestPA	20-40	73.0000 ± 3.4055	31.3000 ± 9.7737	140.0000 ± 12.6219
	41-60	76.5000 ± 4.5787	40.0000 ± 6.5629	142.5000 ± 14.9184
	61-80	77.0000 ± 2.7272	37.5000 ± 11.3114	140.0000 ±14.8049
Cervical Spine LAT	20-40	77.0000 ± 2.7121	30.0000 ± 3.2309	105.0000 ±5.3397
	41-60	75.0000 ± 2.4919	31.2500 ± 3.6860	107.5000 ±5.5677
	61-80	72.0000 ± 2.8174	33.1000 ± 6.0584	110.0000 ±5.5551
Lumbar Spine AP	20-40	90.0000 ± 3.4993	95.0000 ± 12.0515	120.0000 ±6.1345
	41-60	90.0000 ± 6.0205	80.0000 ± 11.1634	120.0000 ±5.8076
	61-80	88.0000 ± 4.8074	80.0000 ± 18.1581	130.0000 ±10.4775

Table 4: Mean exposure parameter used in hospital 2.

Examination type	Age (y)	Mean ± SD		
		kV	mAs	FDD (cm)
ChestPA	20-40	78.0000± 2.4393	35.0000 ± 12.0610	160.0000 ± 14.4453
	41-60	73.0000± 4.3759	31.2000 ± 14.1321	150.0000 ± 22.0028
	61-80	77.0000± 4.1828	31.1000 ± 7.3341	160.0000 ± 18.1330
Cervical Spine LAT	20-40	77.0000± 0.0000	25.0000 ± 2.1650	115.0000 ± 1.6535
	41-60	72.0000± 2.2497	25.0000 ± 0.0000	115.0000 ± 2.2587
	61-80	72.0000± 2.6874	25.0000 ± 1.8633	115.0000 ± 1.8633
Lumbar Spine AP	20-40	76.0000± 9.5735	60.0000 ± 14.6739	125.0000 ± 10.9469
	41-60	80.0000± 7.3297	80.0000 ± 6.2853	125.0000 ± 6.2853
	61-80	80.0000± 3.0310	80.0000 ± 0.0000	140.0000 ± 2.4206

Table 5: Mean exposure parameter used in hospital 3.

Examination type	Age (y)	Mean ± SD		
		kV	mAs	FDD (cm)
ChestPA	20-40	75.0000± 2.4494	20.0000± 0.9798	155.0000± 4.1533
	41-60	70.0000± 2.4052	18.0000± 0.9620	155.0000± 2.4052
	61-80	70.0000± 2.2912	18.0000± 0.9152	150.0000±
Cervical Spine LAT	20-40	65.0000± 0.0000	20.0000±0.0000	100.0000±
	41-60	60.0000± 1.9284	20.0000± 0.0000	110.0000±
	61-80	65.0000± 0.0000	20.0000± 0.0000	100.0000±
Lumbar Spine AP	20-40	80.0000± 0.0000	25.0000± 0.0000	130.0000±
	41-60	80.0000± 0.0000	25.0000± 0.0000	132.5000±
	61-80	80.0000± 0.0000	25.0000± 0.0000	130.0000±

2.4. RAD-CHECK PLUS dosimeter measurements

The X-ray output was measured by Rad-Check Plus, Nuclear Associates Div. of Victoreen, Inc., USA, with serial number 0000107744 and model 06-526, as shown in Figure 1. This compact instrument consists of an electrometer with display electronics and an internal ionization chamber in one compact package with an energy response of ± 5% from 30 kVp to 150 kVp [15].

The exposure is displayed as either

a) Exposure, in Roentgens (0.001 to 1.999 R) or SI units of milligrays (0.01 to 19.99 mGy).

b) Rate, in Roentgens per minute (0.01 to 19.99 R/min) or SI units of milligrays per minute (0.1 to 199.9 mGy/min) [15].

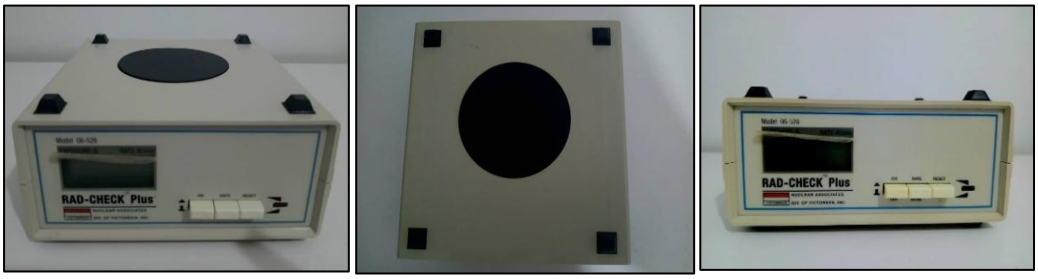

Figure 1. Rad-Check Plus X-ray dosimeter.

The output of each X-ray machine (exposure *X*) was measured using Rad-Check Plus corresponding to different kVs (from 40 to 120 kVp) by a 10 kVp step, constant mAs, and a 100 cm distance from the tube focus, as shown in Figure 2, in order to estimate the doses when data is used in the software. Table 6 displays the output data for all X-ray departments.

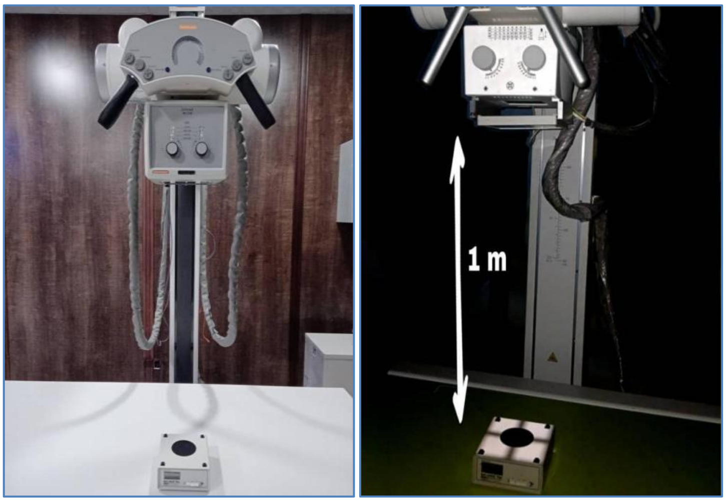

Figure 2. Measurement of output X-ray tube using aRad-Check Plus

Table 6: The X-ray output corresponding to different kVs for each X-ray department.

kVp (V)	Exposure (Roentgen)		
	Hospital 1	**Hospital 2**	**Hospital 3**
40.0000	0.0120	0.0150	0.0080
50.0000	0.0150	0.0230	0.0130
60.0000	0.0210	0.3600	0.0220
70.0000	0.0290	0.0490	0.0320
80.0000	0.0360	0.0630	0.0430
90.0000	0.0460	0.0780	0.0560
100.0000	0.0560	0.0950	0.0700
110.0000	0.0660	0.1130	0.0890
120.0000	0.0770	0.1310	0.1110

First, we converted the exposure in roentgen (R) (from the rad-check plus reading) to the air kerma in gray (Gy), then to µGy/mAs using the relation 1, where K_{air} is air kerma, it is in Gy, and *X* is exposure in R [16]. After applying this relationship to Table 6, it becomes the following table Table 7, so that each patient's data must be entered according to its hospital data.

$$\mathbf{K_{air}} = \mathbf{0.876} \times \mathbf{10^{-2}}\boldsymbol{X} \quad (1)$$

Table 7: The air kerma for each department.

kVp (V)	Air kerma (µGy/mAs)		
	Hospital 1	**Hospital 2**	**Hospital 3**
40.0000	10.5120	13.1400	7.0080
50.0000	13.2640	20.1480	11.3880
60.0000	18.6520	31.5360	19.2720
70.0000	25.9080	42.9240	28.0320
80.0000	31.5360	55.1880	37.6680
90.0000	40.2960	68.3280	49.0560
100.0000	49.0560	83.2200	61.3200
110.0000	57.8160	98.9880	77.9640
120.0000	67.4520	114.7560	97.2360

2.5. CALDose_XSoftwere

The cancer risk was calculated using a software program called CALDose_X 5.0. It has been developed by Kramer et al. The program can determine the effective dose, the absorbed dose for the 29 organs and tissues for adult patients (aged from 20 to 80 years), and the cancer risk for radiographic examinations, using the sex-specific (FAX06 and MAX06) phantoms, which were developed to include ICRP103 tissues and organs. This software is used in the range of the tube potential from 50 to 120 kVp, and the filtration ranges from 2.0 to 5.0 mm of aluminum. These conditions are available in the specifications of the machines in this study. It determines the Incident Air Kerma (INAK) and the Entrance Surface Air Kerma (ESAK), which are measurable quantities based on X-ray equipment output explained in the next paragraph; additionally, it can show an image of the radiation projection on the phantom and the X-ray location when parameters and operational factors are entered [17]. CALDose_X 5.0 used equation 2 to estimate the cancer risk based on the model proposed by Brenner and Huda [18].

$$\mathbf{R} = \sum_{\mathrm{T}} \mathbf{r_T H_T} \quad (2)$$

Where R is the whole-body effective risk, $\mathrm{H_T}$ is the average of the equivalent dose in a tissue or organ and $r_T$is the cancer risk coefficient as reported by the National Research Council (NRC), or it is the lifetime radiation-attributable tissue-specific cancer risks (per unit equivalent dose to tissue T).

knowledge of the biological effects of radiation, the results would be easier to interpret for medical imaging physicists, where lifetime risk can be used to provide risk to different genders and age groups. To this end, the category-based approach has been used to convey the risk from the radiological examination, as shown in Table 8[19].

Table 8: Four broad risk bands for the typical total lifetime cancer risk for patients [19].

Category	Total lifetime cancer risk
Negligible risk	Less than 1 in a million
Minimal Risk	1 in a million to 1 in 100,000
Very Low Risk	1 in 100,000 to 1 in 10,000
Low Risk	1 in 10,000 to 1 in 1,000

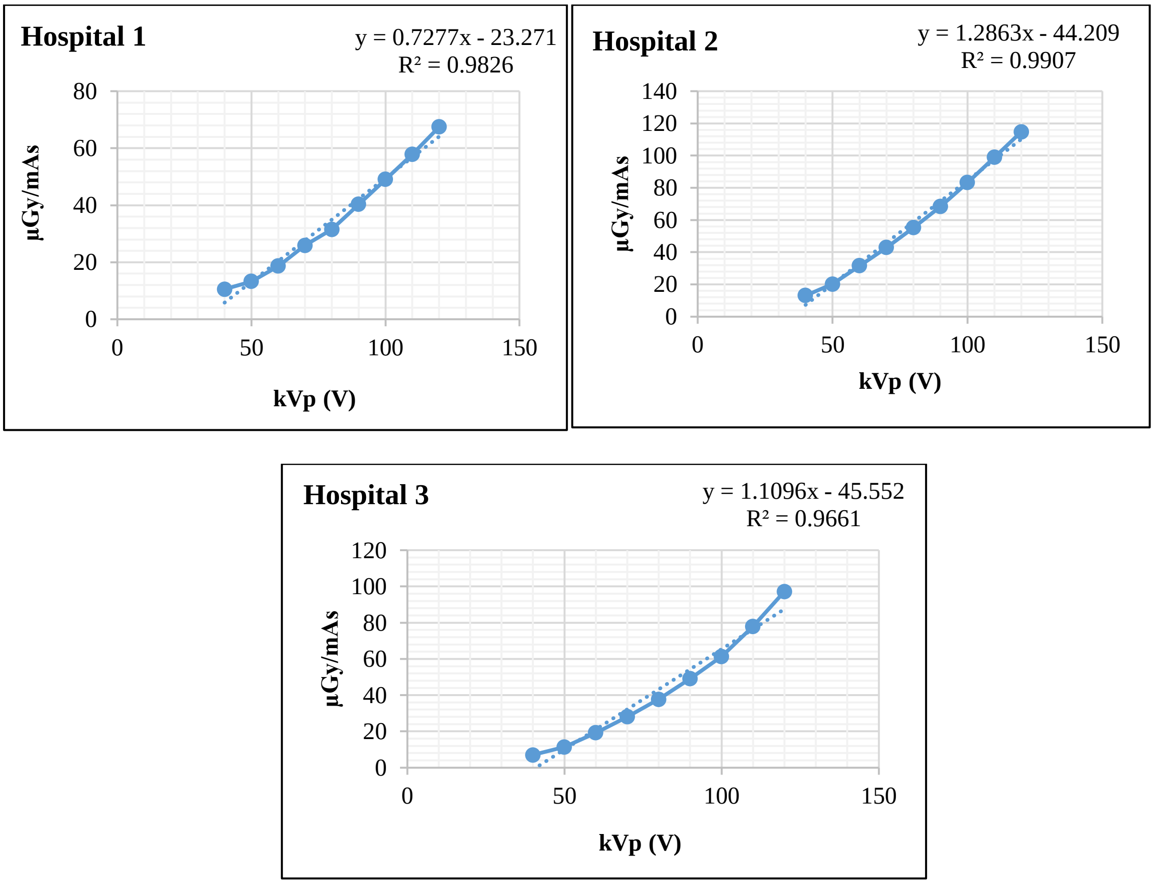

Figure 3. The X-ray output curves obtained using Rad-Check Plus readings.

3. Results and Discussion

Tables 9, 10, and 11 give risks of cancer incidence and mortality values for 100000 persons calculated using CALDose_X 5.0 software using equation 2. These tables give results for chest PA, cervical spine LAT, and lumbar spine AP examinations, respectively, for three radiography departments.

Table 9and Figure 4 show patients undergoing chest imaging aged 20-40 years in Hospital 1 have the highest risks of incidence and mortality from cancer. While patients aged 40-80 who undergo the same type of examination in Hospital 2 are at higher risk of incidence and mortality from cancer than others, on the other hand, patients who undergo medical imaging in Hospital 3 in all their age groups have the lowest risk of incidence and mortality from cancer.

Table 9: Risks of cancer incidence and mortality for 100000 persons for chest PA examinations in three radiography departments.

Hospital	Age (Y)	Risk of cancer incidence	Risk of cancer mortality
Hospital 1	20-40	1.3464	0.9610
	41-60	0.8080	0.7017
	61-80	0.5498	0.5286
Hospital 2	20-40	1.2402	0.9903
	41-60	1.0696	0.9197
	61-80	0.7979	0.7520
Hospital 3	20-40	0.4823	0.3551
	41-60	0.2310	0.1996
	61-80	0.1429	0.1389

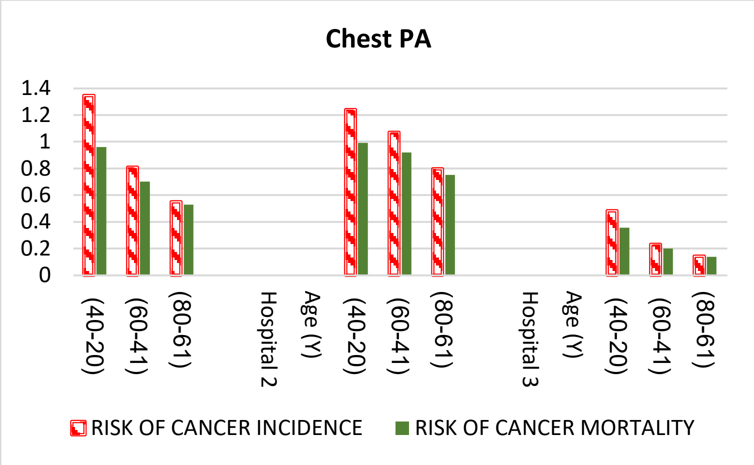

Figure 4. Risks of cancer incidence and mortality for 100000 persons for chest PA examinations in three radiography departments.

According to Table 10 and Figure 5, the largest risks of cancer incidence and mortality are observed in patients attending Hospital 1 who are 20–40 years old and undergo cervical spine imaging.

Table 10: Risks of cancer incidence and mortality for 100000 persons for cervical spine LAT examinations in three radiography departments.

Hospital	Age (Y)	Risk of cancer incidence	Risk of cancer mortality
Hospital 1	20-40	0.8431	0.2820
	41-60	0.3338	0.2555
	61-80	0.2212	0.2105
Hospital 2	20-40	0.6738	0.3062
	41-60	0.3608	0.2824
	61-80	0.2716	0.2596
Hospital 3	20-40	0.4227	0.1279
	41-60	0.1302	0.0934
	61-80	0.1007	0.0967

Patients in the 40–80 age range who have the same type of examination in Hospital 2 are more likely to experience mortality from cancer than those in other age groups, whereas patients in all age groups who get medical imaging in Hospital 3 are the least likely to experience incidence and mortality risks from cancer.

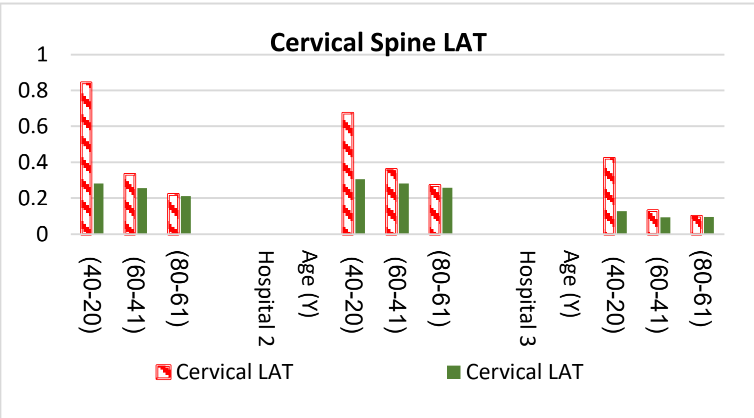

Figure 5. Risks of cancer incidence and mortality for 100000 persons for cervical spine LAT examinations in three radiography departments.

The patients in Hospital 1 who have lumbar spine X-ray imaging and are between the ages of 20 and 40 and 60 and 80 have the highest possibility of cancer incidence and mortality, as shown in Table 11 and Figure 6. While patients in all age groups who undergo medical imaging in Hospital 3 are the least likely to experience incidence and mortality risks from cancer, patients in the 40–60 age range who undergo the same type of examination in Hospital 2 are more likely to experience mortality from cancer than those in other age groups.

Table 11: Risks of cancer incidence and mortality for 100000 persons for lumbar spine AP examinations in three radiography departments.

Hospital	Age (Y)	Risk of cancer incidence	Risk of cancer mortality
Hospital 1	20-40	3.5754	1.7821
	41-60	2.3293	1.2496
	61-80	1.7426	1.4305
Hospital 2	20-40	2.6314	1.4213
	41-60	2.5107	1.3622
	61-80	1.1440	0.7280
Hospital 3	20-40	0.6150	0.3070
	41-60	0.4650	0.2398
	61-80	0.2465	0.1566

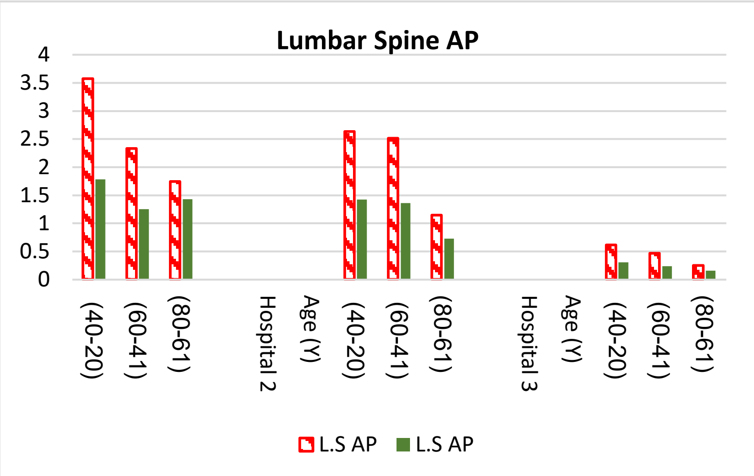

Figure 6. Risks of cancer incidence and mortality for 100000 persons for lumbar spine AP examinations in three radiography departments.

Table 12 shows an overview of the calculated risk values for the three Libyan hospitals and the application of total lifetime cancer risk ranges. Based on the results, the estimated risks in this study generally range from "Minimal" to "Very Low". For example, the highest recorded risk of cancer incidence was 3.5754 per 100,000 (Lumbar Spine AP, Hospital 1, age 20-40). Since this value is between 1 and 10 per 100,000, it is classified as a "Very Low Risk". Conversely, most results for Hospital 3, such as the 0.1429 incidence for Chest PA (age 61-80), fall into the "Minimal Risk" category [20,21].

Table 12: Comparison results in this study with international risk categories [22].

Category	Total Lifetime Cancer Risk	Results in Study
Negligible	Less than 1 in 1,000,000	Values below 0.1 per 100,000.
Minimal	1 in 1,000,000 to 1 in 100,000	Most study results fall here (e.g., 0.1 to 1.0 per 100,000).
Very Low	1 in 100,000 to 1 in 10,000	Higher range results, such as Lumbar Spine AP in Hospital 1.
Low	1 in 10,000 to 1 in 1,000	Typically associated with higher-dose procedures.

4. **Statistical Analysis of Cancer Risks**

A three-way Analysis of Variance (ANOVA) was conducted to examine the effects of hospital setting, patient age, and examination type on the risk of cancer incidence and mortality, as shown in Table 13.

Table 13: Three-Way ANOVA Results for Cancer Incidence and Mortality Risks.

Source of Variation	df	SS	MS	*F*	*p*
		Cancer Incidence			
Examination Type	2	8.386	4.193	17.51	***001. >
Hospital	2	5.274	2.637	11.01	***001. >
Age Group	2	2.436	1.218	5.09	*016.
(Error Residual)	20	4.789	0.239		
		Cancer Mortality			
Examination Type	2	2.546	1.273	18.35	***001. >
Hospital	2	2.246	1.123	16.19	***001. >
Age Group	2	0.278	0.139	2.00	161.
(Error Residual)	20	1.388	0.069		

For Cancer Incidence: The ANOVA revealed a significant main effect for the type of examination, F (2, 20) = 17.51, p< 0.001, indicating that the radiation risk varies substantially across different procedures. Post-hoc comparisons showed that Lumbar Spine AP examinations yielded the highest risk levels compared to Chest PA and Cervical Spine LAT. Additionally, a significant main effect was found for the hospital, F (2, 20) = 11.01, p< 0.001, with Hospital 3 consistently demonstrating the lowest risk values. Age also had a significant effect on incidence risk, F (2, 20) = 5.08, p = 0.016, where risk levels generally decreased with advancing age groups.

For Cancer Mortality: Similar to incidence, mortality risk was significantly influenced by the type of examination, F (2, 20) = 18.34, p< 0.001, and the hospital, F (2, 20) = 16.18, p< 0.001. However, the effect of age on mortality risk did not reach statistical significance, F (2, 20) = 2.00, p = 0.161, suggesting that while age influences the likelihood of cancer onset in this sample, its impact on mortality risk is less pronounced across the studied departments.

The findings of this study highlight significant disparities in radiation-induced cancer risks across different radiography departments. The high significance of the "Hospital" factor suggests that variations in equipment calibration, imaging protocols, or technician expertise may be contributing to the observed differences in patient safety. Specifically, the notably lower risks recorded in Hospital 3 provide a benchmark for optimized radiological practice. Furthermore, the pronounced risk associated with Lumbar Spine AP examinations, as compared to Chest PA, aligns with the higher effective doses typically required for pelvic and spinal imaging. The lack of significant age-related variance in mortality risk despite its significance in incidence warrants further investigation into the biological susceptibility and latency periods associated with radiation exposure in different age cohorts.

5. CONCLUSIONS

According to Table 8, all cancer risk values calculated in this study across all hospitals and types of examinations fall into the "minimum risk" category, ranging between 1 and 100,000. The comparative analysis of estimated cancer risks Hospital 3 as the facility with the lowest potential for radiation-induced cancer across all three examined radiographic procedures and patient age groups. Hospitals 1 and 2 consistently demonstrate higher risk profiles, with the specific examination type and patient age influencing the magnitude of the estimated risk. It is clear that young people have high indicators of cancer, which is why low mAs values are recommended for young people to reduce exposure while still obtaining high-quality diagnostic images. While the risks remain "Minimal" by international standards, the significant variation between facilities-with Hospital 3 consistently showing the lowest risk -suggests that Hospitals 1 and 2 may benefit from more dose-conscious protocols to better align with international best practices for radiation protection. These findings underscore the varying radiation protection practices and exposure parameters across the three hospitals. The consistently lower risk estimates associated with Hospital 3 strongly suggest the implementation of more dose-conscious imaging protocols. While this investigation offers helpful information about the effects of X-ray imaging on human health, more research is needed to include other hospitals, other types of examinations, and other age groups. Specialized dose management training, retraining of technicians, and the involvement of qualified medical physicists are also necessary to standardize radiographic techniques to reduce human error in changing the dose for the same examination across different hospitals. The law of the presence of a medical physics department must also be applied in every radiation hospital, one of whose tasks to conduct quality tests, develop and disseminate clear protocols for digital radiological examinations for the use of radiologists. In addition, patients should be educated and informed about the risks associated with imaging procedures so that they can make informed decisions about their healthcare.

References

1. Kiefer, J. (2012). Biological Radiation Effects. Springer Berlin Heidelberg. https://doi.org /10.1007/978-3-642-83769-2
2. Zhihe Hu , Yan Chen , Shengyi Yang , Shihai Diao , Le Ma & Chunmeng Sh.(2025). Radiation-Induced Biological Effects: Molecular and Cellular Mechanism, and Applications to Radiation/Nuclear Emergency and Cancer Therapy. MedComm (2020). 6(12): e70478 https://doi 10.1002/mco2.70478
3. Nobuyuki Hamada & Yuki Fujimichi. (2014). Classification of radiation effects for dose limitation purposes: history, current situation and future prospects. J Radiat Res. 55(4):629–640. https://doi.: 10.1093/jrr/rru019
4. Harrison, J. D., Balonov, M., Bochud, F., Martin, C., Menzel, H. G., Ortiz-Lopez, P., Smith-Bindman, R., Simmonds, J. R., & Wakeford, R. (2021). ICRP Publication 147: Use of Dose Quantities in Radiological Protection. Annals of the ICRP, 50(1): 9–82. https://doi.org/10.1177/0146645320911864
5. International Commission on Radiological Protection. (2007). The 2007 recommendations of the International Commission on Radiological Protection (J. Valentin, Ed.) (ICRP Publication 103). Annals of the ICRP, 37(2-4). Published for the International Commission on Radiological Protection by Elsevier Ltd. https://doi :10.1016/j.icrp.2007.10.003
6. Anand, P., Kunnumakara, A. B., Sundaram, C., Harikumar, K. B., Tharakan, S. T., Lai, O. S., Aggarwal, B. B. (2008). Cancer is a preventable disease that requires major lifestyle changes. Pharmaceutical Research. Springer New York LLC. https:// doi.org/10.1007/s11095-008-9661-9
7. Peck, D., Henry, F., & Samei, E. (2017). How to Understand and Communicate Radiation Risk. Image Wisely, March. https://www.imagewisely.org/-/media/Image-Wisely/Files/CT/IW-Peck-Samei-Radiation-Risk.pdf
8. Brenner DJ, Hall EJ. (2007). Computed tomography–an increasing source of radiation exposure. *N Engl J Med*; 357: 2277–2284. https://doi : 10.1056/NEJMra072149
9. Chaturvedi, A., & Jain, V. (2019). Effect of Ionizing Radiation on Human Health. International Journal of Plant and Environment, 5(03), 200–205. https://doi.org /10.18811/ijpen.v5i03.8
10. S. A. Kadhim, M. Shareef, Um Albaneen, Mirdan Hreooid, Sadiq Fadl, H. Al-amir. (2024). Exposure to radiation and its health effects on the cardiovascular system. GSC Advanced Research and Reviews. 20(01)، 399-407. https://doi.org/10.30574/gscarr.2024.20.1.0276
11. Mark S Pearce, Jane A Salotti, Mark P Little, Kieran McHugh, Choonsik Lee, Kwang Pyo Kim, Nicola L Howe, Cecile M Ronckers, Preetha Rajaraman, Alan W Sir Craft, Louise Parker & Amy Berrington de González. (2012). Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort studym. The Lancet 380(9840):499-505. https://doi:10.1016/S0140-6736(12)60815-0
12. John D Harrison, R. Haylock, J. Jansen, Wei Zhang & R. Wakeford.(2023). Effective doses and risks from medical diagnostic x-ray examinations for male and female patients from childhood to old age. Journal of Ridological Protection.43(1):1-16. https://doi:10.1088/1361-6498/acbda7
13. Mattsson S. (2016). Need for individual cancer risk estimates in X-ray and nuclear medicine imaging. Radiation Protection Dosimetry. 169 (1-4), pp. 11-16. https://doi: 10.1093/rpd/ncw034
14. Ferid Shannoun, Hajo Zeeb, Carlo Back & Maria Blettner. (2006). Medical exposure of the population from diagnostic use of ionizing radiation in luxembourg between 1994 and

2002.Health Physics. 91(2):154-62. https://doi: 10.1097/01.HP.0000205237.00357.58
15. Fluke® Biomedical. (2005). Nuclear Associates 06-526 & 06-526-2200 RAD-CHECKTM PLUS Operation Manuel. 136201. https://assets.fluke.com/manuals /06_526__omeng0000.pdf
16. Diagnostic Radiology Physics: A Handbook for Teachers and Students. Vienna, International atomic energy agency.Christofides, S., Dance, D. R., Ent, A. D. A. M., McLean, I. D., & Ng, K.-H. (2014).
17. Kramer, R., Khoury, H. J., & Vieira, J. W. (2008). CALDose_X - A software tool for the assessment of organ and tissue absorbed doses, effective dose and cancer risks in diagnostic radiology. Physics in Medicine and Biology, 53(22), 6437–6459. https://doi.org/10.1088/0031-9155/53/22/011
18. Brenner, D., & Huda, W. (2008). Effective dose: A useful concept in diagnostic radiology. Radiation Protection Dosimetry, 128(4), 503–508. https://doi.org/ 10.1093/rpd/ncn056
19. Tootell, A., Szczepura, K., & Hogg, P. (2014). An overview of measuring and modelling dose and risk from ionising radiation for medical exposures. Radiography, 20(4), 323–332. https://doi.org/10.1016/j.radi.2014.05.002
20. Masoumeh Zangeneh & Mohammad Reza Deevband , Behzad Mohsenzadeh. (2020). Lifetime attributable risk of cancer incidence and mortality in routine digital radiology procedures. Clinical Imaging. 67:226-236. https://doi: 10.1016/j.clinimag.2020.08.006
21. Rongshou Zheng , Shaoming Wang , Siwei Zhang , Hongmei Zeng , Ru Chen , Kexin Sun , Li L i [a], Freddie Bray &Wenqiang Wei. (2023). Global, regional, and national lifetime probabilities of developing cancer in 2020. Science Bulletin. 68(21). 2620-2628. https://doi.org/10.1016/j.scib.2023.09.041
22. Michalis Mazonakis, Antonis Tzedakis, Efrossyni Lyraraki & John Damilakis. (2016). Radiation dose and cancer risk to out-of-field and partially in-field organs from radiotherapy for symptomatic vertebral hemangiomas. Medical Physics. 43 (4):1841-1848. https://doi.org/10.1118/1.4944422

تقدير مخاطر الإصابة بالسرطان والوفيات الناجمة عن الإشعاع من خلال التصوير الشعاعي الرقمي في مستشفيا ت مختارة بشمال شرق ليبيا

الملخص

يُعدّ التصوير التشخيصي بالأشعة السينية أسلوبًا أساسيًا لتحديد المشكلات الصحية للمرضى سريريًا؛ إلا أنه ينطوي بطبيعته على زيادة التعرض للإشعاع المؤين، مما يُسهم في الجرعة الإشعاعية التراكمية للمريض. كان الهدف الرئيسي لهذه الدراسة هو حساب خطر الإصابة بالسرطان في التصوير التشخيصي الرقمي باستخدام الأشعة السينية في ثلاثة مستشفيات بشمال شرق ليبيا. وعلى وجه التحديد، حسبت الدراسة معدلات الإصابة والوفيات بالسرطان لدى المرضى البالغين الذين خضعوا لثلاثة فحوصات شعاعية شائعة: تصوير الصدر من الأمام إلى الخلف، وتصوير العمود الفقري العنقي من الجانب إلى الخلف، وتصوير العمود الفقري القطني من الأمام إلى الخلف. تم تحليل مجموعة بيانات تضم 272 مريضًا بالغًا من الذكور والإناث في المستشفيات الثلاثة المحددة، موزعين على النحو التالي: 99 مريضًا في المستشفى الأول (المستشفى 1)، و91 مريضًا في المستشفى الثاني (المستشفى 2)، و82 مريضًا في المستشفى الثالث (المستشفى 3)، مصنفين إلى ثلاث فئات عمرية (20-40، 41-60، و61-80 عامًا)، وذلك لتقييم الجرعة الإشعاعية باستخدام حزمة برامج CALDose_X. أظهرت النتائج أن المرضى الذين تم إدخالهم إلى المستشفى رقم 3 أظهروا خطرًا أقل للإصابة بالسرطان لجميع أنواع الاختبارات مقارنة بالمرضى في المستشفيين 1 و2. وتؤكد النتائج على ضرورة تعزيز الوعي بالمخاطر المرتبطة بالإشعاع وتطبيق استراتيجيات فعالة للتخفيف من هذه المخاطر.

الكلمات المفتاحية: التصوير لشعاعي الرقمي، خطر الإصابة بالسرطان، صورة الصدر الأمامية الخلفية، صورة العمود الفقري العنقي الجانبية، صورة العمود الفقري القطني الأمامية الخلفي.