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Estimation of Uranium Concentration of Cancer Patients' Blood in Babylon Province, Iraq

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ABSTRACT

Radioactive pollution is caused when radioactive materials are deposited in the environment or atmosphere, particularly when their presence is inadvertent, and poses harm to the environment owing to the radioactive decay of the radioactive elements. Exposure to uranium in the workplace or environment can damage cells and increase cancer risk. Uranium, a heavy metal of the actinide family, has negative consequences due to its chemical and radioactive toxicity. The fission-track method with CR-39 evaluated the uranium content in blood samples collected from healthy persons and cancer patients. This method counted the fission tracks in a detector after the nuclear reaction. The data reveal that the lowest value in the group of people with cancer is 1.84±0.36 ppb, while the highest is 2.95±0.32 ppb. This population has an average uranium content of 2.52± 0.32 ppb. The highest result was 1.88± 0.22 ppb, while the lowest was 0.39±0.15 ppb in the healthy group. This population has a mean uranium content of 1.09±0.27 ppb. The statistics show that the uranium content in cancer patients' blood is much higher than that in the blood of healthy individuals.

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INTRODUCTION

Radiation pollution is the release of radioactive materials into the environment, which may harm people and animals. It can be caused by natural sources such as primordial and cosmogenic radionuclides and human activities, including radioactive waste, nuclear weapon tests, accidental releases of radioactive substances, and controlled releases from nuclear facilities (Nies, 2018).

Depleted uranium (DU) is plentiful and cheap since it is a byproduct of the enrichment process, which has been necessary for decades due to the requirement for enriched nuclear fuel. Depleted uranium's chemical and physical qualities make it useful in various military and commercial applications. It finds practical use in a variety of manufactured goods, including gyroscopes, ship ballasts, flywheels, aircraft counterweights, medical device radiation shielding, and rotors (Abbasi, 2021; Merkel & Hasche-Berger, 2008; Miller, 2007).

US forces dropped DU bombs on Iraq in 1991 during the first Gulf War and again in 2003 during the American invasion (Jensen & Lonergan, 2013). The Iraqi people may be exposed to weaponized uranium by inhalation, cutaneous contact, implanted pieces, or ingestion (Keith

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et al., 2013). Due to its pyrophoricity, weaponized uranium produces a cloud of uranium oxide particles of varied solubility upon collision with a hard target (Handley-Sidhu et al., 2010). Human and animal studies have linked inhalation or oral exposure to uranium oxides to an increased risk of cancer and congenital disabilities (Asic et al., 2017; Hindin et al., 2005). Uranium oxides, once ingested, are converted to uranyl ions by a series of metabolic reactions that allow them to form stable bonds with other molecules, such as proteins and bioligands, and then be distributed systemically (Keith et al., 2013). Urine is the primary excretory organ for ingested uranium; the remainder is distributed throughout the bones, kidneys, and liver (Bleise et al., 2003).

Uranium may easily cross both the blood-brain and placental barriers. As shown by several studies, ingesting uranium leads to adverse clinical outcomes such as an increase in reactive oxygen species, DNA damage, and a change in gene expression (Katz, 2014). Local communities are more at risk of unfavorable health impacts from chronic exposure than veteran groups (Faa et al., 2018; Hyams, 2005; Levy & Sidel, 2013). Workers in the scrap metal industry and residents in communities near toxic waste sites like the southern Iraqi city of Umm Qasr, where tanks are stored, are also at risk. (Al-Azzawi, 2016). The literature on uranium concentration in human blood indicates a significant body of research in this field. Numerous investigations on the presence of uranium in human blood and its potential health effects have been carried out, reflecting the importance and relevance of this topic. The breadth of available published literature demonstrates a wide range of investigations encompassing various aspects of uranium concentration, including its sources, exposure pathways, and potential health effects (Abed et al., 2019; Ahmed et al., 2022; Stojsavljević et al., 2020). Fission track analysis with detector CR-39 was used to quantify uranium content in blood samples from Babil governorate residents (Fig.1), including cancer patients and healthy controls. The fission track approach, developed by Fleischer et al. (Henderson, 1978), involves squeezing together two films and subjecting

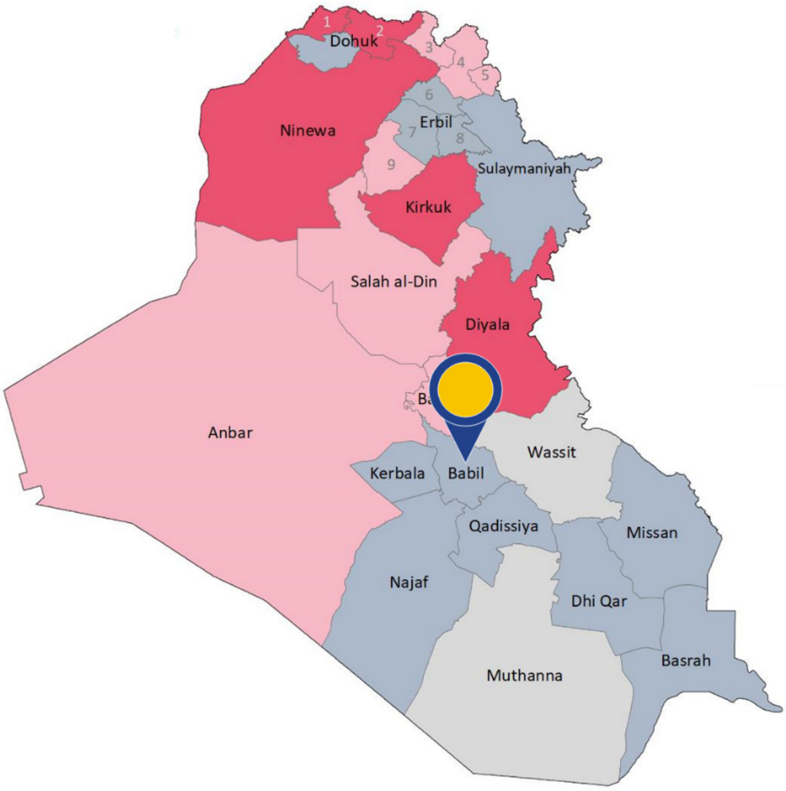


Fig. 1. Babil governorate's study area (European Asylum Support Office., 2021)

Table 1. Cancer patient and healthy group descriptive statistic

	Cancer patients group	Healthy group
Number of males	13	14
Number of females	10	9
Age range/years	2-70	3-70
Average age/years (Males)	40.07	37.35
Average age/years (Females)	37	37.88
Average age/years (Total)	38.73	37.56

them to thermal neutron irradiation to dry the blood. It is the perfect technique for accurately measuring uranium concentrations in human blood. This study aims to use the fission track method with CR-39 to measure the uranium content in the blood of cancer patients and healthy individuals.

MATERIALS AND METHODS

Sample collection

Volunteer male and female blood samples totaling 46 were taken from two groups. Twenty-three blood samples were taken from cancer patients at Imam Sadiq Hospital and the Babylon Oncology Center in Babylon Province for the first group. Seven distinct cancers were represented in these samples (leukemia, liver, lung, stomach, brain, testis, and uterus). In contrast, samples were collected from 23 healthy individuals in the second group. None of the study participants had ever been exposed to uranium in their jobs. Their age, gender, and medical history were collected through a detailed questionnaire. Table 1 shows that the gender ratio was more equitable in these settings. Research was conducted in conformity with the principles outlined in the Declaration of Helsinki (Goodyear et al., 2007) ethical principles for scientific research. We got the patient's informed verbal and analytic permission before collecting samples. The study plan, subject data, and consent form were all reviewed and approved by a regional ethics committee (Babil Health Directorate).

Prepare sample

Blood samples were analyzed for uranium content using neutron radiography (Al-Hamzawi, Jaafar et al., 2014). The blood samples were dried and oxidized in an oven at 100 degrees Celsius for around 13 minutes in the lab. Dry blood powder (weighing in at 0.5 g) was collected and combined with a binding agent of methylcellulose ($C_6 H_{10} O_5$) (weighing in at 0.1 g). The sample mixture was pressed into a pellet with a diameter of 1 cm and a thickness of 1.5 mm. In order to create latent damage to the detector owing to the ^{235}U (n, f) reaction, we coated the pellets on both sides with a CR-39 track detector and placed them on a plate of paraffin wax 5 cm from the Am-Be neutron source with a thermal flounce equivalent to ($3.024\ 10^9$ n cm^{-2}). This exposure lasted for seven days. After irradiation, CR-39 detectors were etched in a (N = 6.25), 60 °C NaOH solution for 5 hours. Figures 2 and 3 show the density of optically recorded induced fission traces at 400x magnification. Surface fission track density measurements revealed a consistent uranium distribution.

Uranium analysis

By comparing the track densities recorded by the CR-39 detectors around the sample pellet to those recorded by the detectors around the standard pellet, we were able to calculate the concentration of uranium in the blood samples using the following relation (Durrani & Bull, 1987; Khan & Qureshi, 1994):

$$C_x = C_s \frac{\rho_x}{\rho_s} \frac{I_s}{I_x} \frac{R_s}{R_x} \quad (1)$$

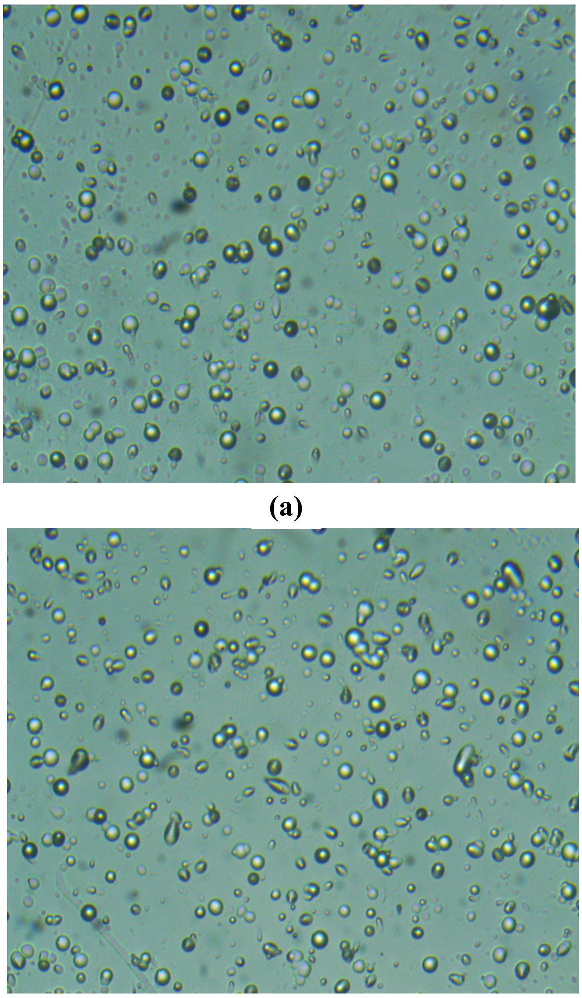
where C_s and C_x are the uranium concentrations in (ppb) in standard and unknown samples, respectively; ρ_s and ρ_x represent the density of fission tracks in (tracks/mm^2) in standard and unknown samples, respectively; I_s and I_x represent the isotopic abundances of ^{238}U and ^{235}U in unknown and standard samples, respectively; Rs and Rx are the range depths of fission fragments in mg cm^{-2} in the detectors covering the standard and unknown samples, respectively. The factors R_s/R_x and I_s/I_x are taken as unity (Singh et al., 1986); hence, Eq. 1 turns into:

$$C_x = C_s \frac{\rho_x}{\rho_s} \quad (2)$$

The relations of track density and uranium content in standard samples are shown in Fig. 4.

Statistical sampling

The data was analyzed using SPSS version 26.0. We conducted an independent sample t-test to determine whether or not the results obtained from all samples of the two groups met statistical significance at the probability level (P) (SPSS).



(a)

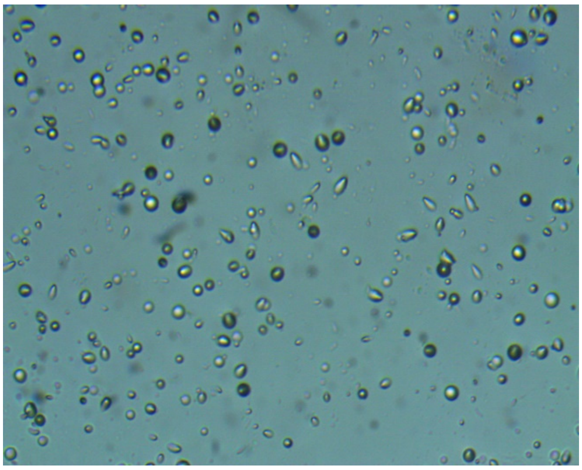
(b)

Fig. 2. The nuclear tracks on the CR-39 detector captured under a microscope for cancer patients group (a) Male (b) Female

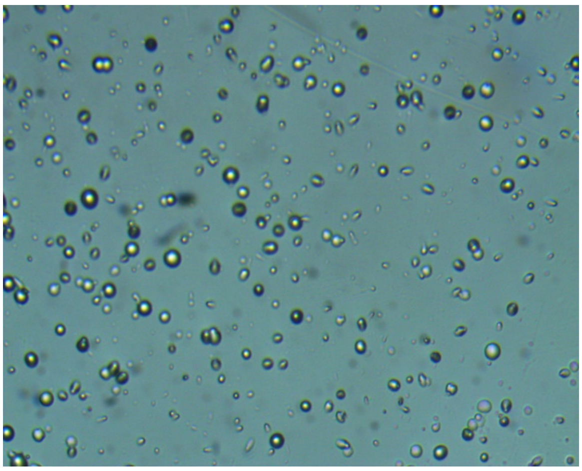
RESULT AND DISCUSSION

Tables 2 and 3 describe the uranium contents in the 46 volunteer blood samples. The uranium levels in the blood samples of people with cancer are shown in Table 2. The lowest value in the cancer patients group was 1.84±0.36 ppb, while the highest was 2.95±0.32 ppb. In these samples, the average content of uranium is 2.52±0.32 ppb. The uranium levels in the blood of healthy subjects are shown in Table 3. Results ranged from a high of 1.880.22 ppb to a low of 0.39±0.15 ppb in the healthy population. Uranium content in this sample averages 1.09±0.27 ppb.

Tables 2 and 3 show information that might suggest some young individuals had higher uranium levels than older individuals. However, there is no correlation between age and uranium levels in the blood of individuals. Uranium levels in an individual's blood may be affected by several variables, including exposure to contaminated water and food. Polluted air and soil, as well as contact with these substances, are environmental variables to consider. It is also worth noting that there are still uranium-containing bullet casings in certain parts of Babylon from the country's wartime history (Handley-Sidhu et al., 2010). Some battle relics are buried in the ground, vulnerable to chemical weathering and eventual corrosion. Schimmack et al. looked at this scenario when they researched depleted uranium munitions in the soil of the former



(a)



(b)

Fig. 3. The nuclear tracks on the CR-39 detector captured under a microscope for healthy group (a) Male (b) Female

Yugoslavia (Schimmack et al., 2005). They demonstrated that uranium-238 leached from the soil is carried downward by precipitation, adding to the groundwater's uranium content. Drinking water from such a source might harm the resident's health (Schimmack et al., 2007). Plants and trees in polluted regions may also use uranium corrosion products (Handley-Sidhu et al., 2010).

A comparison of Tables 2 and 3 shows that the uranium content in the blood of cancer patients is much higher than that in the blood of healthy persons. We considered uranium toxicity a possible cause due to the correlation between higher uranium concentrations and different types of cancer in patients. Most uranium in the body is already bound to other chemicals that can be broken down and used elsewhere in the body. Uranyl ions are generated when tetravalent uranium is oxidized to hexavalent uranium in blood and other bodily fluids. It is common for uranium to form protein complexes in citrate, bicarbonate and plasma (Cooper et al., 1982). The average uranium levels in the blood of cancer patients and healthy persons are shown graphically in Fig. 5.

Figure 5 demonstrates that cancer patients, on average, have a greater uranium concentration in their blood than healthy people. The uranium levels significantly differed between cancer patients and healthy groups using an independent sample t-test ($P < 0.001$).

The environment in Iraq has suffered dramatically since the first Gulf War in 1991 and the military operations to invade Iraq in 2003, which have had detrimental effects on the health of the Iraqi people and pose a danger to the environment (Al-Hamzawi, Jafaar et al., 2014). This explains why cancer rates in Iraq continue to rise each year. In the blood of both male and female individuals who have cancer, the mean uranium concentration is 2.47±0.31 ppb and 2.58±0.34 ppb, respectively, as shown in Fig. 6. The average uranium levels in healthy males and females are 1.06 ± 0.27 and 1.14 ± 0.28 ppb, respectively. The research found that female cancer patients and healthy controls had higher average uranium concentrations than male cancer patients and controls. This is because women have a total blood volume of 4-5 liters, while males have a volume of 5-6 liters, which adds to this disparity (Fox, 2011). Uranium levels did not vary significantly ($P > 0.05$) between the sexes in either the groups of patients or healthy.

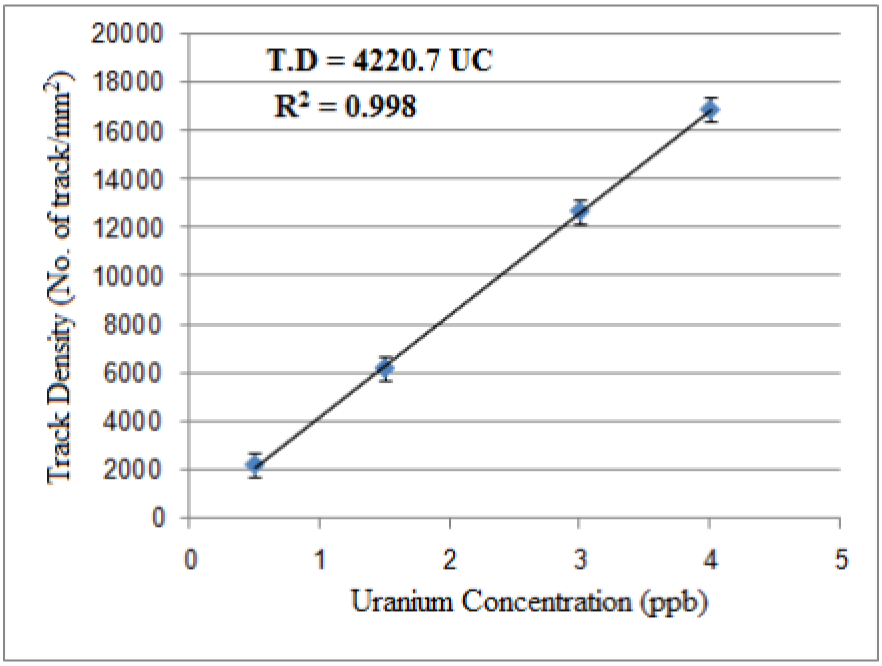


Fig. 4. The relationship between track density and uranium concentration (ppb) of the standard blood samples (Al-Hamzawi, Jaafar, et al., 2014)

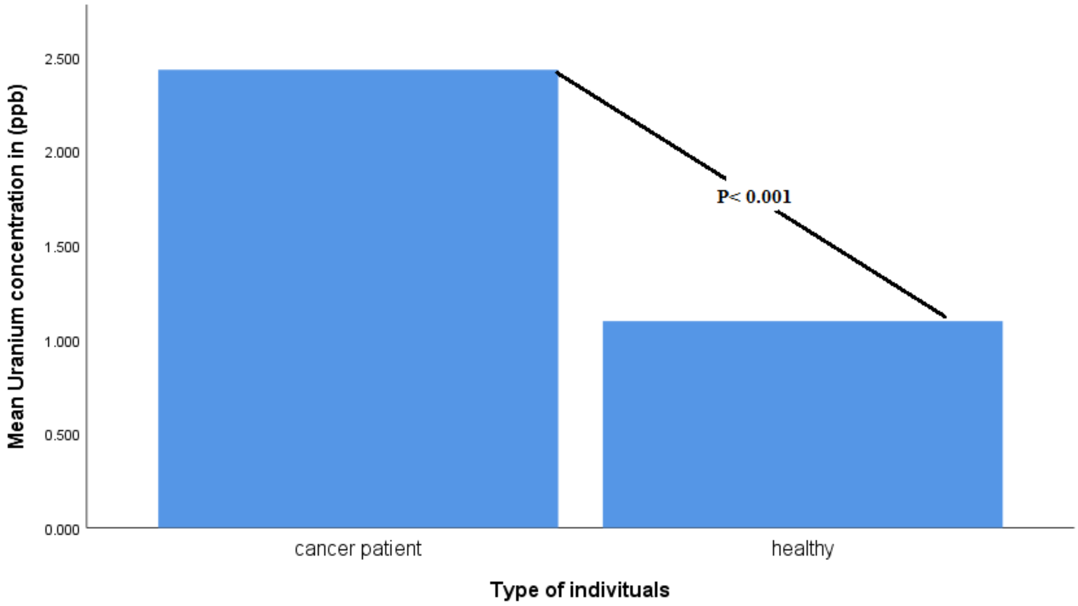


Fig. 5. Avarege blood uranium contents in cancer patients and healthy groups

Table 2. Cancer patients' blood uranium levels

Sample code	Gender	Age	Cancer type	Smoker	Uranium concentration (ppb)
CB 01	Male	70	Testis	yes	2.19 ± 0.20
CB 02	Female	52	Lung	yes	2.89 ± 0.37
CB 03	Male	52	Stomach	No	2.05 ± 0.38
CB 04	Female	33	Uterus	No	2.75 ± 0.37
CB 05	Male	40	Brain	No	2.49 ± 0.25
CB 06	Male	40	Testis	yes	2.61 ± 0.29
CB 07	Male	55	Liver	yes	2.37 ± 0.38
CB 08	Female	50	Brain	No	2.60 ± 0.48
CB 09	Male	56	Lung	No	2.01 ± 0.37
CB 10	Female	60	Stomach	yes	2.79 ± 0.43
CB 11	Male	53	Testis	yes	2.81 ± 0.25
CB 12	Female	57	Stomach	yes	2.21 ± 0.28
CB 13	Male	65	Leukemia	No	1.84 ± 0.36
CB 14	Male	21	Lung	No	2.65 ± 0.24
CB 15	Female	27	Uterus	No	2.78 ± 0.36
CB 16	Male	29	Stomach	yes	2.84 ± 0.32
CB 17	Female	56	Brain	No	2.16 ± 0.20
CB 18	Male	20	Leukemia	No	2.78 ± 0.30
CB 19	Female	19	Lung	No	2.08 ± 0.25
CB 20	Male	9	Leukemia	No	2.64 ± 0.41
CB 21	Female	14	Leukemia	No	2.81 ± 0.29
CB 22	Female	2	Brain	No	2.76 ± 0.43
CB 23	Male	11	Liver	No	2.95 ± 0.32
			Mean ± Std Error		2.52 ± 0.32

* CB represents cancer blood.

Table 3. Uranium in healthy blood samples

Sample code	Gender	Age	Smoker	Uranium concentration (ppb)
HB 01	Male	70	No	1.58±0.29
HB 02	Female	53	No	1.08±0.34
HB 03	Male	50	yes	1.13±0.34
HB 04	Female	36	No	0.71±0.27
HB 05	Male	42	No	0.56±0.24
HB 06	Male	37	yes	1.33±0.25
HB 07	Male	55	yes	1.53±0.37
HB 08	Female	50	No	1.77± 0.43
HB 09	Male	59	yes	1.88±0.22
HB 10	Female	50	No	1.50±0.31
HB 11	Male	59	yes	1.46±0.36
HB 12	Female	46	No	0.81±0.24
HB 13	Male	69	yes	0.53±0.22
HB 14	Male	15	No	0.56±0.27
HB 15	Female	24	No	1.38±0.27
HB 16	Male	34	yes	1.44±0.24
HB 17	Female	45	No	1.50±0.28
HB 18	Male	11	No	0.91±0.27
HB 19	Female	23	No	1.04±0.28
HB 20	Male	9	No	1.001±0.29
HB 21	Female	14	No	0.49±0.16
HB 22	Male	3	No	0.55±0.28
HB 23	Male	10	No	0.39±0.15
		Mean ± Std Error		1.09±0.27

* HB represents healthy blood

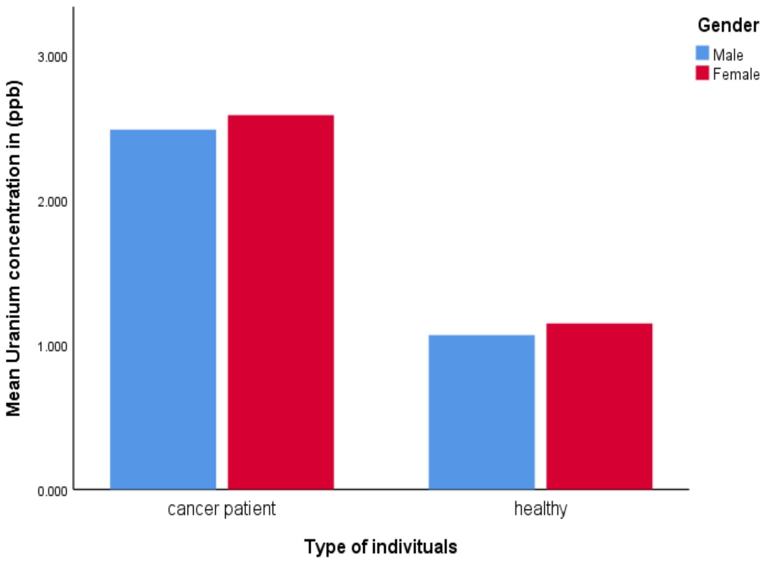


Fig. 6. Uranium levels in blood samples as a function of gender

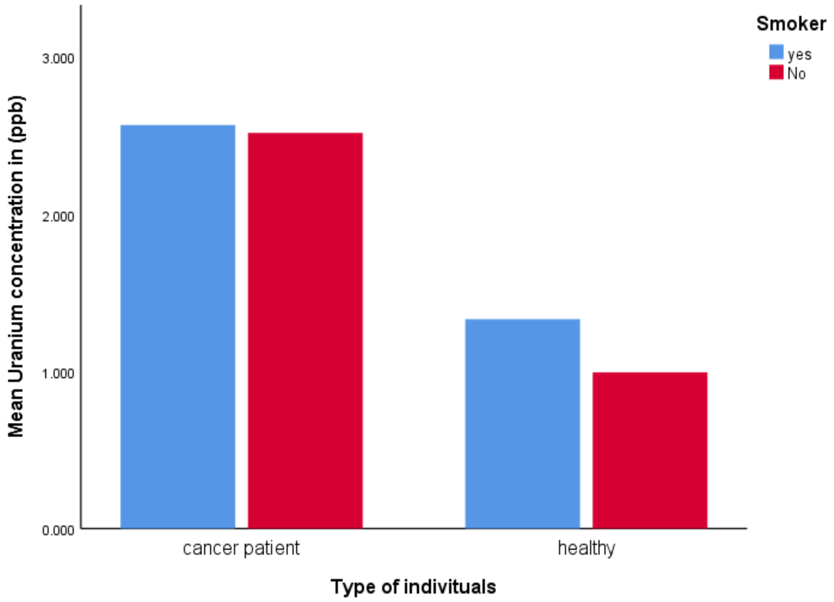


Fig. 7. Avarege uranium contents in study group blood samples by smoking habitas a function of smoking habit

Table 4. Uranium levels in blood worldwide

Country	Uranium concentration	Reference
Kosovo	7.99 ± 3.1 ng/l (Control Subjects) 12.76 ± 4.0 ng/l (Thermo Power Plant workers)	(Zeneli et al., 2015)
Russia	0.04 µg/l (Occupationally exposed workers)	(Ivanenko et al., 2013)
Serbia	0.05–0.08 ng g^{-1} (women) 0.03–0.07 ng g^{-1} (men)	(Stojsavljević et al., 2019)
United States	0.025 µg/l	(Rice et al., 2010)
Argentina	0.06 ng/l (Pregnant women)	(Lu et al., 2015)
Iraq	2.463 ± 0.30 µg/l (women with breast cancer) 1.205 ± 0.30 µg/l (women without breast cancer)	Present work

The average levels of uranium found in blood samples taken from all of the participants in the study are plotted versus their smoking habits in Figure 7. The average concentration of uranium in the blood samples of smokers in the patient group is 2.57 ± 0.28 ppb, which is a factor of 0.05 higher than the concentration in the non-smoking patient group. The uranium concentration in the blood samples of healthy people in the healthy control group is 1.34 ± 0.32 ppb, which is a factor of 0.35 higher than the concentration in the non-smoking control group. This suggests that people who smoke cigarettes have a greater risk of being exposed to uranium than those who do not smoke cigarettes.

The findings produced in this study were compared, in large part, to the data that had been published earlier, as indicated in Table 4. The findings indicate that the average uranium concentrations discovered in the blood of cancer patients in the current research are greater than those reported in prior investigations. This was determined by comparing the results of both sets of studies. Military actions in Iraq, especially depleted uranium munitions, may have contributed to this elevated element level.

CONCLUSION

The uranium levels found in cancer patients’ blood are much higher than those found in the blood of healthy controls ($P< 0.001$). These findings demonstrate a causal link between the patient's condition and their blood uranium levels. Women have a more excellent uranium content in their blood than men do. Females have a smaller overall blood volume (4-5 L) than males (5-6 L), which may explain why women tend to have lower birth weights. The average uranium level of ill smokers' blood is higher than that of healthy smokers' blood. In contrast, healthy smokers' blood's average uranium content is higher than nonsmokers' blood. This indicates that cigarette smokers are more likely to be exposed to uranium than nonsmokers.

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The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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