

Research Paper



Radiological study on smoke and smokeless tobacco: a concise review on health impacts assessment

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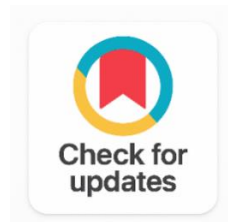
Smokeless Tobacco

Radiological Hazards

Radioactivity

Insulin Resistance

Hypertension



ABSTRACT

Background: Radioactive isotopes from uranium and thorium decay chains in tobacco products, whether smoked or smokeless, have high carcinogenic and biological risks. Although the use of smokeless tobacco has increased, there are under-characterised health effects for both radiological and reproductive health, and it is perceived as a safer alternative to smoking.

Objective: To assess, in detail, the radiological consequences of smoke and smokeless tobacco, and their impact on male and female reproductive health and fetal outcomes.

Methods: Systematic literature review was carried out for articles published up to 2022 in various databases such as PubMed, ResearchGate, and Google Scholar. Studies that investigated the radioactivity content of tobacco products and the health effects were considered.

Results: In both smoke and smokeless tobacco products, an increase in radioactivity was found. Chronic tobacco exposure has been shown to be associated with ovarian dysfunction, impaired oocyte quality, hormonal disruption, insulin resistance, hypertension, acute respiratory illness, and osteoporosis. Preliminary findings suggest negative impacts on female fertility, foetal growth and long-term neonatal health.

Conclusions: Smoking (all types) is a major risk factor for both radiological and reproductive health. Tobacco use is estimated to claim more than 8 million lives each year, and is projected to kill more than 1 billion people in the 21st century. Public health policy needs to be informed by an increased awareness of these radiological risks and dispel the myth of the complete safety of smokeless tobacco.

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1. INTRODUCTION

Smoking has been linked to the inhalation of some naturally occurring radionuclides, which has been regarded one of the major causes of lung cancer [1]. Smoking tobacco exposes users to minute levels of radiotoxic substances as ^{210}Pb , ^{210}Po , and ^{238}U . Cigarette smoking has been recognized as a major, serious health problem and a factor in the high death and morbidity rates of smokers and passive smokers in many nations. According to several studies, smokers' lipids, blood, and livers contain significantly more cadmium than those of non-smokers [2], [3]. According to studies, lung cancer claims the lives of 3000 nonsmoking persons each year. According to studies, second-hand smoke from other people's cigarettes causes 3000 non-smoking adults to pass away from lung cancer every year [3]. Asthma, respiratory infections, shortness of breath, high blood pressure, elevated blood sugar levels, and sleep problems are among the usual ailments reported for both cigarette and shisha smokers. Evidence showing that smoking shisha is not safer than smoking cigarettes was produced by [4].

Smoking shisha has quickly gained popularity in Nigeria's major cities. The variables that are mediating this abrupt shift include smoking for enjoyment, smoking for its stimulating effect, experimentation, or perceived safety versus cigarette smoking [5]. The practice is popular among young people, older people, and university students in public places like restaurants and hotels as well as at social gatherings. The study examined the presence of radionuclides in samples of cigarettes, shisha, and shisha charcoal acquired from Kano marketplaces using gamma spectroscopy [6]. For the majority of people, smoking tobacco is a way to unwind at the dawn of the twenty-first century. There are numerous ways to consume tobacco, including cigarettes, smokeless tobacco, hookah, cigars, pipes, etc. The World Health Organization (WHO) estimates that 1.27 billion people use tobacco worldwide, and that tobacco use causes 5.4 million fatalities annually. Nicotine, a substance that can lead to addiction, makes up the majority of tobacco. Wilhelm Heinrich Posselt and Karl Ludwig Reimann, both German physicians, were the first to extract nicotine from tobacco. In addition to nicotine, tobacco smoke also contains radioactive substances such polonium 210, formaldehyde, lead, arsenic, ammonia, carbon monoxide, and tobacco-specific nitrosamines (TSNAs). These substances are linked to practically all of our body's organs being affected, and they are also psychologically influencing our minds [7].

People who smoke tobacco are exposed to a number of harmful substances. It has negative consequences on human health: it shortens life expectancy, raises morbidity, and raises medical expenses. In addition to harming smokers, tobacco smoke also has negative consequences on others who inhale it, including pregnant women since it can have harmful effects on the fetus. Smoking increases the risk of developing a number of harmful medical conditions, including cancer, cardiovascular disease, ischemic stroke, and osteoporosis. Babies who are exposed to cigarette smoke on a regular basis develop asthma and respiratory tract illnesses. Additionally, it makes immune cells less active and intensifies allergic reactions. Recent studies have also confirmed the connection between smoking and vascular and degenerative neurological conditions such as Parkinson's disease (PD), Alzheimer's disease (AD), stroke, and anxiety. Neuro-developmental problems have been associated with higher maternal smoking during pregnancy. Nearly 0.48 million deaths a year in the United States of America are attributed to active and passive smoking. Smokers made up 15.5% of the population in 2016 compared to 20.9% in 2005, although no discernible change has yet been seen. The World Health Organization (WHO) predicts that by 2030, smoking-related deaths will account for almost nine million deaths annually. The purpose of this review is to evaluate the radiological biological danger of smoke and smokeless tobacco. The elements of smoke and smokeless tobacco, the ways they are consumed or inhaled, the ways they affect human organs and the therapies required to stop this dangerous habit and its addictive qualities.

1.1 Components of Tobacco Smoke

There are about 7000 toxic and deadly chemicals found in tobacco, including tobacco in cigarettes. A complex concoction of molecules can be found in cigarette smoke. The use of a filter allows the separation of cigarette smoke into its two component parts, gas-phase smoke and tar. Radicals in both periods differ significantly. In comparison to gas-phase smoke, which contains more than 10^{15} radicals per puff, tar has roughly 10^{17} per gram. Nitric oxide, dienes, and reactive olefins are a few examples of the gas-phase free radicals with short half-lives, measured in seconds. But radicals in the tar phase, including catechol and hydroquinone radicals, are stable and have a long half-life that can reach months. Nicotine is the main tobacco smoke component that causes addiction and many other negative effects. Heavy metals (lead, arsenic), carbon monoxide, hydrogen cyanide, formaldehyde, nitrosamines, ammonia, polycyclic aromatic hydrocarbons (PAHs), radioactive elements, and several other substances are also components. Accumulation of heavy metals in tobacco represents a direct pathway for their entry into the human body [8]. The brain responds to acute exposure to tobacco smoke by reducing overall brain activity, activating the thalamus, prefrontal cortex, and visual cortex systems, and increasing the levels of dopamine in the ventral striatum/nucleus accumbens. Chronic nicotine or tobacco smoke exposure results in decreased basal ganglia monoamine oxidase (MAO) A and B activity as well as decreased thalamic and limbic 42 nAChR availability.

The primary acute consequence of smoking is an increase in neurotransmission, which has cognitive effects like enhanced attention that is sustained over time, quicker reaction times, arousal, and motivation.

1.2 Exposure to Secondhand Smoke (SHS) and its Health Effects

Risks SHS, the tobacco smoke produced by regular smokers, continues to be a major health risk on a global scale. Adults who are exposed to SHS are more likely to develop serious cardiovascular and respiratory conditions, such as lung cancer, leukemia, and lymphoma. The risk of breast cancer in women and brain tumors in children can both be raised by the toxic compounds found in cigarette smoke. SHS exposes infants to an alarming risk of SIDS, ear infections, colds, pneumonia, and bronchitis, more severe asthma, and sluggish lung development. In public spaces, about 50% of children daily breathe tobacco smoke-polluted air. According to the WHO, SHS exposure resulted in more than 0.603 million fatalities in 2004, accounting for 1.0% of all deaths globally. Additionally, mounting research suggests that SHS also has an impact on smokers. SHS was responsible for 28% of child fatalities in 2004. According to the GATS 2009–2010 estimates, secondhand smoke exposure in India was estimated to be 29.9% at work and 29.0% in public areas. However, according to GATS 2016–2017 estimates, 23.0% of adults in public areas and 30.2% of people in the workplace, respectively, were exposed to secondhand smoking [9].

1.3 Toxic Effects of Tobacco on Reproductive Health and Mechanisms

Smokeless Tobacco is a general phrase that encompasses a wide range of tobacco products that can be used as smoking cessation methods. These items can be ingested orally or nasally, and the varieties may differ from one region to another. The most common ones are "chewing tobacco," which is made of dried tobacco leaves, "snuff," which is made of finely ground dry or moist tobacco, "mishri," which is made of baked or burnt ground tobacco, and "gutkha," which is a concoction of tobacco with slaked lime, areca nuts, catechu (extract from the acacia plant), and spices. The habitual use of tobacco in all of its forms is pervasive and poses a severe threat to worldwide public health. Particularly, the use of smokeless tobacco has grown significantly as a result of its widespread availability and the false perception that it is less harmful than smoking. Numerous studies have conclusively shown that smoking causes severe diseases like cancer, insulin resistance, hypertension, acute respiratory infection, osteoporosis, etc. Its potential significance in negatively influencing reproductive capabilities and outcomes in women of reproductive age and during pregnancy has also been suggested by a small but rising body of research. This article offers a current summary of the body of research on the harmful effects of smokeless tobacco use on female reproductive health, on pregnant women, and on children. Existing research indicates a link between chronic smokeless tobacco use and ovarian shape and function deterioration, oocyte quality, hormonal

disturbances, fetal development, and long-term health impacts on the fetus. Greater awareness of the risks associated with smokeless tobacco products may result from improved understanding of these issues [10].

Additionally, although a small number of studies have indicated no effect, it has been discovered that smoking tobacco generally reduces the volume, concentration, and total number of sperm. On male reproductive characteristics and its impact on genome integrity, Figure 1 showed some consequences of tobacco smoke. Smoking was linked to lower sperm counts and a rise in sperm with aberrant morphology (defects in the head, neck, and tail) [10].

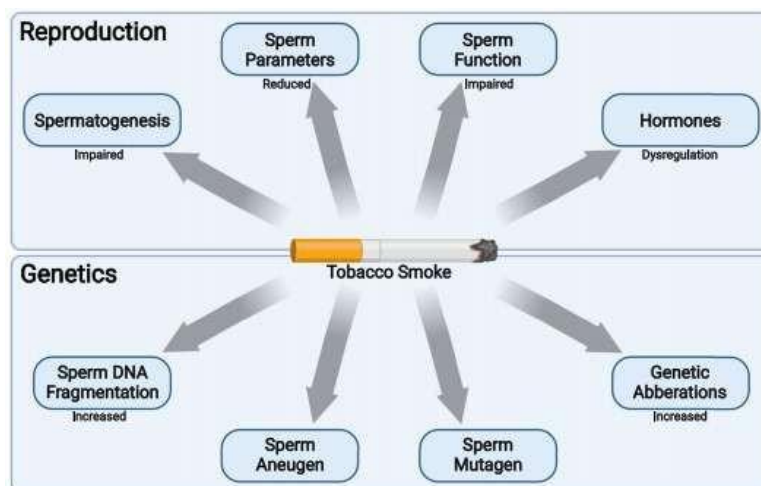


Figure 1. Effects of Tobacco Smoke on Male Fertility and Its Impact on Genome Integrity [10]

Semen or sperm parameters (concentration, volume), sperm function, and reproductive processes (spermatogenesis) have all been proven to be affected by tobacco smoke (motility). The cumulative effects of tobacco smoke's effects on male fertility include increased sperm DNA fragmentation, sperm mutagenesis, and sperm aneuploidy, as well as the fact that it is considered an endocrine disruptor [10]. The processes through which tobacco smoke decreases male fertility are shown in Figure 2. Reactive oxygen species (ROS) generation from tobacco smoke is known to increase, which in turn leads to the emergence of oxidative stress. The lipid peroxidation and increased DNA strand breaks brought on by an excessive concentration of ROS change the characteristics and activities of sperm.

Increased amounts of pro-apoptotic cytokines are produced as a result of increased ROS generation, which has also been found to cause the development of apoptosis. This can further result in increased sperm DNA damage and, ultimately, reduced male fertility. The anterior pituitary's ability to secrete luteinizing hormone (LH) and follicle-stimulating hormone (FSH), which are necessary for testosterone production and spermatogenesis, can be interfered with by tobacco smoke substrates. Some of these poisons can also cross the blood-testosterone barrier, which can have an immediate impact on spermatogenesis and testosterone synthesis and secretion. Smoking tobacco is therefore a recognized endocrine disruptor [10].

1.4 Effects of Tobacco Smoking on other Biological System

Smoking raises the risk of cardiovascular events and death in CKD patients, contributes to the progression of renal disease, and results in the failure of kidney transplants [11]. Smoking causes vascular occlusion in the kidneys, kidney cell damage, insulin resistance, an increase in low-density lipoprotein cholesterol, an increase in blood pressure and difficulty controlling hypertension, an increase in oxidative stress, an increase in endothelin-1 and vasopressin, a decrease in nitric oxide, physical and psychological dependence, an increase in the risk of kidney cancer, an increase in the risk of lung disease, and chronic obstructive pulmonary disease. Smoking also has other negative effects like early aging and increased infection risk Figure 3. For men, smoking accounts for 35% of cancer deaths, and for women, it accounts for 15%. It reduces life expectancy by 13.2 years for males and 14.5 years for women. Smoking also harms

one's teeth and oral health. According to studies, smoking and tooth cavities are closely related [11]. The patient's kidney failure may worsen as a result of dental caries. Additionally, the use of nephrotoxic medications and analgesics for infections and dental caries may result in further kidney damage. Numerous chemical substances, 250 of which are hazardous, are found in cigarette smoke. Over fifty of them are cancerous. These include substances like carbon monoxide, formaldehyde, hydrogen cyanide, nicotine, naphthylamine, cadmium, tar, and arsenic, to name a few. All of these chemicals harm the kidney as well. The causes of smoking and its effects account for almost 8 million deaths worldwide each year. Kidney failure risk is lower if a smoker stops smoking. The smoking of a CKD patient is formally equivalent to suicide in light of all of this evidence. Everyone should not smoke, not only those with CKD. For someone with CKD, smoking is like to getting hit in the brain with a bullet [11].

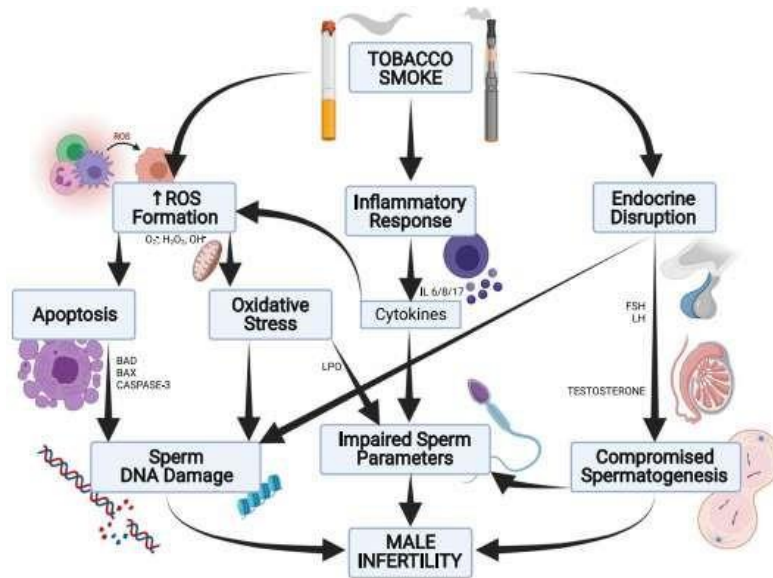


Figure 2. Mechanisms through which Tobacco Smoke Affects Male Fertility [10]

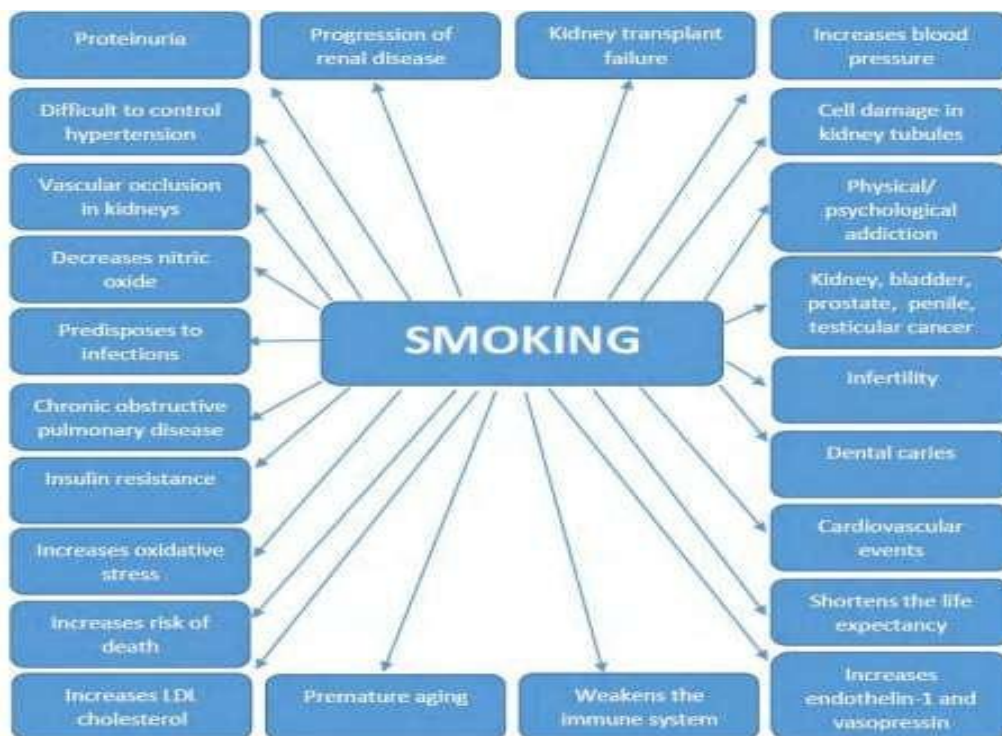


Figure 3. Hazard of Tobacco Smoking on other Biological System [11]

The leading factor in deaths that are avoidable is smoking. Nearly 20% of people in the world smoke cigarettes. 90% of adult smokers started while they were 18 or younger. Millions of children and adults smoke all over the world, which is unacceptable. Millions of fatalities would be avoided if individuals worldwide would stop smoking, which would significantly lower the number of cancer deaths. Nearly all systems and organs start to regenerate when a CKD patient stops smoking, and kidney deterioration starts to reduce or even reverse [11]. The immune system is strengthened, proteinuria and end-stage kidney disease progression are slowed, cardiovascular mortality, stroke risk, and cancer risk are all reduced, lung functions are enhanced, and as a result, quality of life is increased. Smoking costs the global economy \$1 trillion, 400 billion every year. Dialysis and other CKD therapies cost approximately \$ 1.5 trillion yearly. No patient in a developing or underdeveloped nation will pass away from lack of access to dialysis thanks to this funding. No one in the world would go hungry, and the approximately 30,000 people who die of hunger every day would not, if the money spent on cigarettes were used to help feed the [11], [12].

2. METHODOLOGY

2.1 Search Strategies

Tobacco smoking, its impact on sperm parameters, and its role as a mutagen were all topics covered in a literature search of all pertinent information. These searches used a variety of electronic resources, including Google Scholar, PubMed, and Research Gate. In order to do the searches, keywords like "tobacco/cigarette smoking," "smokeless tobacco," "sperm DNA fragmentation," "mutagen," and "radiological dangers" were used. The only writing available was English-language articles. For the purpose of elucidating mechanisms of action, this publication also contains research findings that examined how tobacco smoke affected animals. A summary of the number of scientific articles published on these subjects during a period of five years, as obtained from several data bases, is shown in Table 1. It should be noted that the terms "tobacco smoke" and "cigarette smoke" are used interchangeably in this text.

2.2 Study Selection and Eligibility

A detailed systematic assessment of existing studies was conducted in order to assess the consequences of radiological impacts on tobacco products like smoking and smokeless tobacco. Only research on tobacco's radiological health consequences was taken into account. Additionally, full-text articles that were printed in journals that underwent peer review were assessed. Three reviewers examined the relevance of potential study names and abstracts before accessing the whole text. In a subsequent step, the same reviewers independently decided which whole published papers met the prerequisites. In addition, the bibliographies of the collected papers were thoroughly scrutinized for potential brand-new citations [13], [14], [15].

2.3 Data Extraction

Data on tobacco and its variety products, radionuclide concentrations, effective doses, and radiological consequences like cancer risks were taken from each study. Table 1 summarizes all the data extracted from literatures.

3. RESULTS AND DISCUSSION

Table 1. Overview of the Results

Tobacco Sample	Method	Radionuclide & Concentrations	Effective Dose	Cancer Risk	Reference
Cigarette tobacco	Alpha Spectrometry	^{210}Pb : 11.79 ^{210}Po : 15.00	111.89 $\mu\text{Sv/y}$	-	[15]
moassel tobacco	Alpha Spectrometry	^{210}Pb :7.08 ^{210}Po :9.12	225.76 $\mu\text{Sv/y}$	-	[15]

Unrefined tobacco	NaI (Tl) detector	238U: 27.57 40K: 87.14	17.19 nSv	-	[16]
Refined tobacco	NaI (Tl) detector	232Th: 13.71 238U: 4.57	2.23 nSv 7.79 nSv	7.79nSv	[16]
Cigarette	Gamma Spectroscopy	40K: 567.60 238U : 14.38 232 Th: 7.40	894.32 μ Sv/y	3.13×10^{-3}	[6]
Shisha	Gamma Spectroscopy	40K: 258.12 238U : 8.44 232 Th:5.45	4,975.80 μ Sv/y	17.42×10^{-3}	[6]
Shisha charcoal	Gamma Spectroscopy	40K: 1129.14 238U :16.93 232 Th: 7.90	15,185.39 μ Sv/y	53.15×10^{-3}	[6]

[13] Claimed that smoking harms the lungs in a number of ways, raising the risk of inflammation and worsening disease outcomes. It may impede the body's normal immune response to outside intruders like viruses. According to a study by [7], tobacco use, in whatever form, is a common way for the majority of people to unwind at the dawn of the 21st century. Cigarettes, smokeless tobacco, hookah, cigars, pipes, and many other products can all be made with tobacco. Nearly every organ in the body is thought to be affected by tobacco, and there is also evidence that smoking has psychological effects on the mind. Early on, dental healthcare professionals recognized how tobacco use could affect oral health. They then counseled tobacco users about the need to stop using tobacco. In their study on tobacco use, [14] discovered that male fertility is more at risk from smoking more than five cigarettes per day for more than two years, as well as from passive smoking. To regulate and end tobacco use, more national and international initiatives are required. Similar research on Shisha and cigarette users was done by [6], and the findings showed that smokers were at risk for serious illnesses. These could come from the quantity of radioactive, carcinogenic, and harmful to living creature's radioactive isotopes from the uranium and thorium decay series present. Shisha consumption in Kano has increased, hence it was judged necessary to look into the radioisotopes in the goods available in the city markets. Gamma spectroscopy was used to analyze 30 samples 10 from charcoal products for cigarettes, shisha, and other uses and look for radioisotopes. The average values for the activity concentrations of 40K, 238U, and 232Th, absorbed dose rates, annual effective doses, radium equivalent activity indices, and excess lifetime cancer risks of Shisha products were tabulated in Table 1. The majority of these parameter values were discovered to be greater above the UNSCEAR (2000) and WHO recommended limit, indicating substantial health concerns to smokers.

[15] Looked into the levels of 210Pb and 210Po activity in the most widely used brands of cigarettes and moassel tobacco in Egypt using alpha spectrometry, the samples were identified using the spontaneous deposition technique. In all tobacco brands, it was out that the activity concentration of 210Po was larger than that of 210Pb. Cigarettes contained higher activity levels of 210Pb and 210Po than moassel tobacco. In comparison to moassel tobacco, which had values of 7.08 and 9.12 mBq/g, 210Pb and 210Po had average activity concentrations of 11.79 and 15.00 mBq/g and 11.79 and 9.12 mBq/g, respectively Table 1. Calculations were made of the everyday activities that a smoker inhales into their lungs as well as the inhalation effective doses brought on by smoking cigarettes and shisha. The findings showed that the annual effective doses of 210Pb and 210Po attributable to shisha smoking were two times higher than the equivalent values due to cigarette smoking. As a result of smoking 20 cigarettes per day, the results also showed that the yearly effective doses of 210Pb and 210Po are 14 and 16 times, respectively, more than the annual dosages ingested by diet. In comparison, the yearly effective doses of 210Pb and 210Po from shisha smoking (27 g moassel tobacco per day) are 26 and 33 times, respectively, more than the annual dosages ingested through diet. Additionally, more research is required to determine the impact of the charcoal used in moassel ignition on the ingestion of these substances.

In tobacco and tobacco-based soil, dosage rates were examined by [16]. NaI (Tl) detector is the device used to measure the amount of uranium, thorium, and potassium (model: 802). The absorbed dosage rate was found to be 38.66 nGyh⁻¹ in the soil samples, 14.02 nGyh⁻¹ in the unrefined samples, and 1.82 nGyh⁻¹ in the refined samples, respectively. These results are less than the 51nGyh⁻¹ global average.

For the soil sample, the unrefined sample, and the refined sample, the annual effective dosage equivalents were found to be 47.41nSv, 17.19 nSv, and 2.23 nSv, respectively. These levels are much below the permissible global standards of 70 μ Sv. The finding for refined tobacco's excess lifetime cancer risk was 7.79 nSv, which is far lower than the globally acceptable limit of 0.29 mSv. Additionally, research revealed that the amount of radioactive elements on tobacco leaves and soil increased in proportion to the quantity of fertilizers or pesticides used on the tobacco farm.

Due to the hazard associated with the exposure to these radionuclides and inhalation of the short-lived decay products of radon, international bodies and governmental organization such as International Commission on Radiological Protection and Environmental Protection Agency have adopted strong measures at minimizing such exposure [17], [18].

4. CONCLUSION

All tobacco and tobacco products examined in the literature are unsafe for consumption because they exceed the WHO-recommended limits. Therefore, it is suggested that the government and interested groups work to reduce cigarette use. It is necessary to accurately measure the intake of various radioactive and chemical materials in order to determine the potential radiological dangers associated with smoking and smokeless tobacco; regrettably, the literature only contains a limited amount of information on this subject. To learn more about the consumption of these substances (radionuclides and hazardous heavy metals), particularly in the context of cigarette smoking, more studies are required. The impact of other tobacco use behaviors, such as chewing and snuffing, has to be further studied.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
B. Samaila	✓	✓	✓	✓		✓		✓	✓	✓	✓			
A. A. Shehu	✓	✓	✓	✓			✓	✓	✓	✓				
A. Bako		✓	✓	✓	✓	✓	✓				✓	✓	✓	✓

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Informed Consent

All participants were informed about the purpose of the study, and their voluntary consent was obtained prior to data collection.

Ethical Approval

Not Applicable.

Data Availability




The data that support the findings of this study are available from the corresponding author upon reasonable request.

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