



The Story of Cigarettes and Tobacco That Captured the World with Radiation

Zekiye Hasbek^{1,a,*}

¹ Department of Nuclear Medicine, School of Medicine, Sivas Cumhuriyet University, Sivas, Türkiye

*Corresponding author

Review

History

Received: 07/04/2025

Accepted: 09/05/2025

Copyright



This work is licensed under
Creative Commons Attribution 4.0
International License

ABSTRACT

Cigarettes, which are scientifically proven to cause diseases and deaths, have radiation effects in addition to many toxic substances. In this review, we aimed to talk about the radioactive content of cigarettes, which is known by a small number of people and which we think may be one of the most effective efforts to prevent the cigarette epidemic that affects everyone, men, women, young, old and children, especially in developing countries. We aimed to support the fight against smoking with this review article.

Keywords: Cigarette, tobacco, radiation, lung cancer, Polonium 210

Dünyayı Esir Alan Sigara ve Tütünün Radyasyonla Hikayesi

Derleme

Süreç

Geliş: 07/04/2025

Kabul: 09/05/2025

Telif Hakkı



Bu Çalışma Creative Commons Atıf
4.0 Uluslararası Lisansı
Kapsamında Lisanslanmıştır.

Öz

Hastalıklara ve ölümlere neden olduğu bilimsel olarak kanıtlanan sigaranın birçok toksik madde içeriği dışında radyasyon etkisi de bulunmaktadır. Biz de bu derlemede, özellikle gelişmekte olan ülkelerde olmak üzere kadın, erkek, genç, yaşlı, çocuk herkesi etkileyen sigara salgınının önüne geçmek için gösterilen çabaların en etkinlerinden biri olabileceğini düşündüğümüz ve az sayıda kişi tarafından bilinen radyoaktif içeriğinden bahsetmeyi amaçladık. Biz bu derleme makale ile sigaraya karşı savaşa destek olmayı amaçladık.

Anahtar Kelimeler: Sigara, tütün, radyasyon, akciğer kanseri, Polonyum 210

Introduction

The harmful effects of cigarette smoke and tobacco on health have been known for years because they contain many toxic substances such as nicotine, tar, carbon monoxide and arsenic.¹ In this review, we would like to talk about the relationship between smoking and radiation in addition to this classical information. Perhaps explaining the radiation effect of cigarettes may be the most effective method to prevent the epidemic of smoking, which is sweeping the whole world, especially in developing countries, affecting everyone, men, women, young, old and children, and to make them quit smoking. We aimed to support the fight against smoking with this review article.

Discovery of Cigarettes

Although the date of the first use of tobacco is not known, it is known that it was brought to Europe by Christopher Columbus and his friends as a gift from the natives during their discovery of America at the end of the 1400s. Tobacco, which was accepted as a spiritual inspiration in Africa, became widespread, especially in England and France with propaganda that it was beneficial and even a medicine.² In fact, in 1559, Jean Nicot, the ambassador of France to Portugal, presented tobacco to the French Queen by mentioning that it was good for cough, asthma, headache, stomach diseases and gynecological diseases; for this reason, tobacco was called "Queen's weed" or "Ambassador's weed" and Nicot became the unforgettable ambassador of tobacco history.³ It is astonishing that the first edition of the Merck Manual, which is considered one of the basic books of medical sciences, published in 1889, included a suggestion that cigarettes could be used in the treatment of bronchitis and asthma "with today's knowledge".⁴

The Relationship Between Smoking and Radiation

Let us now look at how tobacco leaves are exposed to radiation during tobacco production. Radon (Rn) is a colorless, odorless, tasteless and completely radioactive gas with atomic number 86 and atomic weight 222, which is formed by the natural decay of uranium and radium found in almost all rocks and soils. During its decay, it is converted into polonium, which emits alpha radioactivity ($^{222}_{86}\text{Rn} \rightarrow ^{218}_{84}\text{Po} + ^4_2\text{He}_2$). Radon moves upwards through soil and rocks. For this reason, it accumulates especially in basements in contact with the ground and can even enter buildings through openings in the walls. Polonium 210 (Po-210) and lead 210 (Pb-210), which are released by the breakdown of radon, a naturally occurring radium product in the soil, can be taken up by the roots of tobacco plants. In addition, fertilizers rich in polyphosphates used to increase productivity in tobacco plants also contain Pb-210 and Po-210. As the plant grows, these radioactive products stick especially to the sticky hairs on the underside of tobacco leaves, called trichomes. It is also very difficult to wash off with rain. Tobacco growers have been aware of the presence of this

alpha radioactivity in tobacco smoke since about 1960. And even in 1980, it was discovered that acid washing was highly effective in removing Po-210 from tobacco leaves. Unfortunately, however, the cigarette industry has avoided the use of acid washing because the acid environment would ionize nicotine into a poorly absorbable form in smokers' brains, thus depriving them of the much sought-after instant "nicotine hit" sensation, as well as "economic costs to farmers" and "unknown environmental consequences of acid leaching into the soil".⁵

Polonium 210, known to be present in cigarettes, shows a radiation effect 4 times higher than uranium due to its alpha radioactivity ($^{210}_{84}\text{Po}_{126} \rightarrow ^{206}_{82}\text{Pb}_{124} + ^4_2\text{He}_2$). It has a 138-day physical half-life. The characteristic of alpha radiation is that it can be stopped even by a thin layer of paper or skin. However, when inhaled, it enters the body and lodges in the airways (especially in bifurcations of segmental bronchi). Polonium was discovered by Marie Skłodowska Curie and her husband Pierre Curie in 1898 and named "Polonium" in honor of Marie Curie's native Poland. Although its discovery is old, the assassination of former Russian agent Alexander Litvinenko with Po-210 in November 2006 drew attention to how lethal this radioactivity can be.⁶ In the literature, there is very striking data on the amount of radioactivity exposed by smoking. According to Scott et al., ingestion of as little as 1 µg of Po-210 can be fatal.⁷ Ingestion (or inhalation) of a few milligrams is expected to be fatal for everyone. Ingestion (or inhalation) of a few milligrams would be expected to be fatal for everyone. Fatal ingestion of Po-210 causes severe damage leading to tissue necrosis in the bone marrow, spleen, liver, kidney, skin, lymph nodes and possibly other areas of the body. According to their study, Little and Radford estimated that people who smoked for 25 years would receive a radiation dose of 2 Sv due to Po-210 in the bronchial epithelium of the bifurcation region of the inferior lobes of the lungs.⁸ The annual carcinogenic risk of a smoker who smokes 20 cigarettes per day is equivalent to having 300 chest X-rays.⁹ According to the results of a review by Karagueuzian et al., the annual radiation dose to a person who smokes 2 packs of cigarettes per day for 20 years is 330 mSv due to the radioactivity in them.⁵ This radiation dose is thought to accumulate cumulatively after 20 years of smoking. To understand how high this dose is, it is necessary to state one of the basic principles of radiation safety rules: "The highest allowable dose value to which a radiation worker can be exposed is 20 mSv per year".

Cigarette, Lung Cancer and Radiation

According to WHO data, more than 8 million people die each year due to tobacco use.¹⁰ Lung cancer is the leading cause of cancer-related deaths (18.7%).¹¹ The incidence of lung cancer among lifelong nonsmokers falls within the National Cancer Institute's (NCI) definition of "rare" cancer (less than 40,000 cases per year, age-standardized incidence rate <15 per 100,000).¹² The argument that most smokers who cannot quit take refuge behind is that

"smoking is not the only etiology of lung cancer." However, it must be admitted that this information does not change the fact that tobacco exposure is by far the greatest risk factor for lung cancer worldwide.

Although it varies according to the filters used, some of the Po-210 content in cigarettes is inhaled by the smoker (5-37%) and the other part is released into the atmosphere.¹³ These released radioactive decay products bind to smoke particles.¹⁴ Some of them are so small that they can remain suspended in the air almost indefinitely. As a result, some of these airborne particles can be inhaled by passive smokers and smokers themselves. According to a study by Begy et al., the average radiation dose from active smoking was estimated to be $8.36 \pm 0.91 \mu\text{Sv/year}$, while the dose reaching the respiratory system from passive smoking was estimated to be $5.92 \pm 0.49 \mu\text{Sv/year}$.¹⁵ In other words, it is clear that "if you are in an environment with active smokers, you are as much as if you smoke". Even though the radiation doses calculated in this study may seem low at first glance, the long half-life of the exposed radiation and the fact that it cannot be excreted out of the body in continuous smokers due to its accumulation in the place where it is located cause an increase in radiation exposure.

Effective attempts to reduce tobacco use are being made all over the world. According to a study conducted by Malvezzi et al. in the five most populous European Union countries, it is predicted that a 35% reduction in cancer mortality rate could be achieved by 2035 with a reduction in the risk of lung cancer through tobacco control and further efforts to control overweight and obesity, alcohol consumption, infection and related neoplasms, as well as improvements in screening, early detection and treatment.¹⁶ However, the prevalence of tobacco use among adults and adolescents in Europe is increasing, especially among young people.¹⁷ Three cost-effective interventions are attempted to be implemented for tobacco control banning/restricting smoking in public and workplaces; direct health warning labels on cigarette packs and other tobacco products; and increasing the price of cigarettes and tobacco products through higher taxes.¹⁷ Of these, the increase in the average tobacco tax is considered to be one of the most effective methods tried to be implemented by WHO. However, only the European region has reached the 75% tax criterion recommended by the WHO.¹⁸ In Turkey, smoking was banned in all indoor areas (except restaurants, bars and cafes) with the "Smoke-Free Air Zone" campaign in May 2008 and this ban was extended to restaurants, coffee houses, bars and cafes in July 2009. Although there is no precise data, it is thought that this ban has also raised awareness in terms of reducing passive exposure in homes.

In the past, men were more likely to smoke than women, but in recent years it is clear that women are increasingly becoming smokers. Perhaps as a result of this situation, according to GLOBOCAN 2018 data, lung cancer was the 3rd most common cancer in women (8.4% of all

cancers), but according to 2022 data, it is now the 2nd most common cancer in women (9.4% of all cancers).^{11,19} Cigarettes, which were considered a serious taboo for women in Europe until the first half of the last century, became an expression of women's emancipation as women's demands increased, it was frequently written and said that it was not a product exclusively for men, and the desire for social equality increased. In a study conducted, 58.5% of the respondents answered "to try cigarettes out of curiosity", 46.6% answered "for friendship (friends, schoolmates, colleagues) and imitation", and 15% answered "to face a difficult period" when asked why they started smoking.²⁰ Unfortunately, in today's society, tobacco companies have succeeded in recruiting women as smokers, perhaps even more than men, through their efforts to make smoking a "symbol of modern femininity and freedom". The visual media's emphasis that smokers are financially and professionally successful, emphasized in popular movies, and television shows, and even showing improved social status, has been skillfully implanted in the subconscious of all young people. In fact, the most important factor for both sexes to start smoking is social acceptance and admiration. Smoking seems to be the most unifying part of social activity today. Friends and family smoking are the most predisposing factors for smoking. According to Oh et al., the risk of starting smoking is 12 times higher in individuals with half or more of their friends who smoke.²¹ It is obvious that young people with lower socio-economic conditions and lower education levels are also more vulnerable to increased tobacco smoking. Why is smoking more common in developing countries with low socioeconomic levels? Although this may seem like a paradox, perhaps the most important factor in the increase in the prevalence of cigarette use in the past years was its low price. It was even distributed to soldiers free of charge in our country. Due to reasons such as a lack of information about the harmful effects of cigarettes on health and the lack of attention given to this issue by the policies in developing countries, smoking has become increasingly common in underdeveloped countries.

There are different studies evaluating the relationship between smoking, gender and cancer. According to Bain et al., tobacco exposure does not effect risk differences between men and women.²² It is suggested that factors such as the depth of inhalation during tobacco use, cigarette type and tar content and differences in population sampling in the studies have an effect. According to an analysis by May et al., the overall mortality rate from lung cancer and tumor grade at the time of diagnosis is higher in men than in women.²³ However, they also reported that this situation is not related to tobacco use alone, but may be affected by many conditions such as other environmental exposures, especially asbestos, the higher immune system in women compared to men and their tendency to respond better to cytotoxic and targeted therapies, the effect of estrogen, etc.

Conclusion

As a result, although people are attracted to its pleasurable effect, tobacco and cigarettes, apart from their chemical toxins, are undeniably harmful to our body, especially the lungs, due to their alpha radioactivity content, which is known to have a very high ionizing effect. Unfortunately, while cigarette companies continue to earn at ever-increasing rates thanks to this epidemic, the health of millions of people who continue to smoke, knowing, unknowing or unwilling to know the harm to their health, is under threat. The best advice to smokers is to quit smoking, and if they are unable to do so, to reduce the risk by smoking outdoors where the radioactivity suspended in the air will not be inhaled by passive smokers and themselves. I think that the most effective solution to this issue would be for politicians to make plans to reduce radiation content, such as making acid washing mandatory for cigarette manufacturers and monitoring the content of fertilizers used in tobacco production. I also think that it would be much more effective to write warnings such as "Caution: Contains Radioactivity" on cigarette packages or to have radiation warning signs on cigarette packages.

References

1. L. Breslow, "Cigarette Smoking and Health," Public Health Rep. 95, 451 (1980)
2. Gately, I. Tobacco: the story of how tobacco seduced the world. New York: Grove Press, 2001.
3. Barış Yi. Tütün Kullanımı Tarihçesi, http://www.toraks.org.tr/sub/sigarasiz/TuTuN_KULLANIMININ_TARiHcESi_I_Baris.pdf Erişim Tarihi: 09/12/2021
4. Zaga, V., Lygidakis, C., Chaouachi, K., & Gattavecchia, E. Polonium and lung cancer. *Journal of oncology*, 2011;(1), 860103.
5. Karagueuzian, H. S., White, C., Sayre, J., & Norman, A. Cigarette smoke radioactivity and lung cancer risk. *Nicotine & Tobacco Research*, 2011;14(1), 79-90.
6. McFee, R. B., & Leikin, J. B. Jerrold B. Death by polonium-210: lessons learned from the murder of former Soviet spy Alexander Litvinenko. In *Seminars in diagnostic pathology WB Saunders*, 2009. p. 61-67.
7. Scott, Bobby R. Health risk evaluations for ingestion exposure of humans to polonium-210. Dose-response, 2007, 5.2: dose-response. 06-013. Scott.
8. Little, John B.; Radford JR, Edward P. Polonium-210 in bronchial epithelium of cigarette smokers. *Science*, 1967, 155.3762: 606-607.
9. Zagà, V., & Gattavecchia, E. Polonium: the radioactive killer from tobacco smoke. *Pneumologia (Bucharest, Romania)*, 2008; 57(4), 249-254.
10. World Health Organization (WHO), Tobacco, https://www.who.int/health-topics/tobacco#tab=tab_1.
11. Bray, F., Laversanne, M., Sung, H., Ferlay, J., Siegel, R. L., Soerjomataram, I., & Jemal, A. (2024). Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: a cancer journal for clinicians*, 2022; 74(3), 229-263.
12. Thun, M. J., Hannan, L. M., Adams-Campbell, L. L., Boffetta, P., Buring, J. E., Feskanich, D., ... & Samet, J. M. Lung cancer occurrence in never-smokers: an analysis of 13 cohorts and 22 cancer registry studies. *PLoS medicine*, 2008;5(9), e185.
13. Carvalho, F. P., & Oliveira, J. M. Polonium in cigarette smoke and radiation exposure of lungs. *Czechoslovak Journal of Physics*. 2006; 56(1), D697-D703.
14. Tidd, M. J. The big idea: polonium, radon and cigarettes. *Journal of the Royal Society of Medicine*, 2008;101(3), 156-157.
15. Begy, R. C., Simon, H., & Kelemen, S. 210 Po inhalation due to smoking: a dose estimation. *Journal of Radioanalytical and Nuclear Chemistry*, 2015;306, 257-261.
16. Malvezzi, M., Santucci, C., Boffetta, P., Collatuzzo, G., Levi, F., La Vecchia, C., & Negri, E. European cancer mortality predictions for the year 2023 with focus on lung cancer. *Annals of Oncology*, 2023; 34(4), 410-419.
17. Bafunno, D., Catino, A., Lamorgese, V., Pizzutilo, P., Di Lauro, A., Petrillo, P., ... & Galetta, D. Tobacco control in Europe: a review of campaign strategies for teenagers and adults. *Critical Reviews in Oncology/Hematology*, 2019;138, 139-147.
18. World Health Organization (WHO). 2023 Global Progress Report on Implementation of the WHO Framework Convention on Tobacco Control. WHO; 2024. Accessed January 16, 2024. <https://fctc.who.int/publications/m/item/2023-global-progress-report>
19. Bray, F., Ferlay, J., Soerjomataram, I., Siegel, R. L., Torre, L. A., & Jemal, A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: a cancer journal for clinicians*. 2018; 68(6), 394-424.
20. Zagà, V., Serafini, A., Amram, D. L., Barbeta, C., Bandelli, G. P., & Cattaruzza, M. S. Tobacco smoke and socio-environmental gender differences. *Tabacologia*. 2024; 22(1), 28-41.
21. Oh DL, Heck JE, Dresler C, Allwright S, Haglund M, Del Mazo SS. Determinants of smoking initiation among women in five European countries: a crosssectional survey. *BMC Public Health*. 2010; 10:74
22. Bain, C.; Feskanich, D.; Speizer, F.E.; Thun, M.; Hertzmark, E.; Rosner, B.A.; Colditz, G.A. Lung cancer rates in men and women with comparable histories of smoking. *J. Natl. Cancer Inst*. 2004, 96, 826–834.
23. May, L., Shows, K., Nana-Sinkam, P., Li, H., & Landry, J. W. Sex differences in lung cancer. *Cancers*, 2023; 15(12), 3111.