

# Does Smoking Weaken the Immune System: A Narrative Review

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**How to cite this paper:** Alubaidi, A.M.R. (2024) Does Smoking Weaken the Immune System: A Narrative Review. *Health*, 16, 553-560.  
<https://doi.org/10.4236/health.2024.166037>

**Received:** April 8, 2024

**Accepted:** June 17, 2024

**Published:** June 20, 2024

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## Abstract

Smoking has a complex impact on the immune system, affecting both innate and adaptive immunity. It can exacerbate pathogenic immune responses and attenuate defensive immunity, leading to a higher susceptibility to infections and certain diseases. The chemicals in cigarette smoke, such as nicotine and carbon monoxide, can alter immune cell functions and inflammatory responses. Smoking can also have long-term effects on the immune system, with some changes persisting even after quitting [1]. According to a Penn Medicine Physician, the Medical Oncologist Dr. David Porter, “People who are smokers tend to get sicker from infections”, “It may be that smoking impacts the immune system’s ability to respond appropriately”. Thus, such individuals within smoking exposure history might be considered as immunocompromised due to the altered and weakened immune system. Cigarette smoking is a prevalent habit with far-reaching health implications. Among its many adverse effects, smoking significantly alters the immune system’s functionality [1].

## Keywords

Smoking, Immunity, Immune System, Immunocompromised, E-Cigarettes, Hookahs

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## 1. The Effects of Smoking on Overall Health

Per the CDC of USA (Centers for Disease Control and Prevention), on average, compared to individuals who have never smoked, smokers suffer for years with more health problems due to their smoking and ultimately die earlier by a decade or more than nonsmokers.

Per the CDC of USA (Centers for Disease Control and Prevention), smokers’ overall health is worse, and they are sick more often than nonsmokers. Smokers

need to go to the healthcare provider more often and they are admitted to the hospital more often than nonsmokers. Smokers miss more work than nonsmokers. This costs American businesses, and American workers who smoke, billions of dollars every year.

Smoking plays a dual role by both intensifying pathogenic immune responses and weakening the mechanisms of defensive immunity. This dichotomy results in an increased risk for a variety of diseases, including respiratory and cardiovascular conditions, as well as autoimmune disorders. Smoking affects key immune cells across both innate and adaptive systems, such as T cells, B cells, macrophages, and natural killer cells. Molecular pathways like NF $\kappa$ B and MAP kinases are notably influenced by smoking, leading to altered immune regulation. The cessation of smoking begins to reverse these effects; however, some immune system alterations may have lasting consequences. This underscores the importance of abstaining from smoking to maintain optimal immune function and overall health [1].

## 2. The Impacts of the Chemicals in the Cigarette

Per the CDC of USA (Centers for Disease Control and Prevention), Cigarette smoke contains more than 7000 chemical compounds. Many of them can interfere with the immune system. Diseases can progress when the immune system is not working effectively. Diseases that can be worsened by smoking include viral and bacterial infections, periodontal or gum disease, bacterial meningitis, infections that occur after surgery, rheumatoid arthritis, Crohn's disease that is an Inflammatory Bowel Disease which is a serious disease of the digestive system, and cancer.

According to the Government of the Victoria State, Australia, The highly damaging components of tobacco smoke include:

- Tar: is the word for the solid particles suspended in tobacco smoke. The particles contain chemicals, including cancer-causing substances (carcinogens). Tar is sticky and brown, and stains teeth, fingernails, and lung tissue. It contains a mix of carcinogenic compounds that can stain lung tissues and destroy antibodies, leading to a compromised immune system. Specifically, tar has immunosuppressive effects, which means it can weaken the body's innate immune response. For instance, it can suppress or decrease the phagocytic activity of neutrophils, which are crucial for destroying the pathogens [1].
- Carbon monoxide (CO) which is a poisonous gas. It is odorless and colorless and, in large doses, quickly causes death because it takes the place of oxygen in the blood. In people who smoke, the carbon monoxide in their blood makes it harder for oxygen to get to their organs and muscles. CO binds with hemoglobin in the blood more effectively than oxygen, forming carboxyhemoglobin, which reduces the oxygen-carrying capacity of the blood which can lead to hypoxia in tissues, including those of the immune system, impairing their function [2].

- Oxidizing chemicals: are highly reactive chemicals that can damage the heart muscles and blood vessels of people who smoke. They react with cholesterol, leading to the build-up of fatty material on artery walls. Their actions lead to heart disease, stroke, and blood vessel disease.
- Metals: Tobacco smoke contains several metals that cause cancer, including arsenic, beryllium, cadmium, chromium, cobalt, lead, and nickel.
- Radioactive compounds: tobacco smoke contains radioactive compounds that are known to be carcinogenic.

### 3. Smoking Studies that Were Published

A conclusion for a study that was published online in November 2016 stated that “Ample evidence has shown that both innate immunity and adaptive immunity are susceptible to cigarette smoke, which interrupts immunological homeostasis, causes various diseases, and exerts paradoxical effects on immune and tissue cells through regulating NFκB and MAPK signaling as well as histone modification. Cigarette smoke acts as a double-edged sword that either exacerbates pathological immune responses or attenuates the normal defensive function of the immune system, possibly owing to the complexities and functional diversities of cigarette smoke components and individuals’ medical condition. Nevertheless, smoking plays a harmful rather than beneficial role in either case [1].”

Per a paper that was published 2004 by Doll R, Peto R, Boreham J, and Sutherland I, about the effects of smoking on the immune system stated that “Nicotine has been shown to be an immunosuppressive agent that can modulate innate and adaptive immune responses in the human body [3].”

Per a Narrative Review that was published 2020 by Jiang C, Chen Q, and Xie M, cigarette smoke suppresses and decreases neutrophils phagocytic activity and affects chemotaxis, kinesis, and cell signaling. Thus, cigarette smoke inhibits the release of reactive oxygen species (ROS), therefore compromising pathogen killing by neutrophils and other cells of the innate immunity [4].

Smoking increases the incidence of infections and aggravates both the progress and the prognosis of infectious diseases overall. Smoking is one of the main risk factors and one of the main modulators for infections in the respiratory tract, digestive tract, reproductive tract, and other systems in humans, increasing the prevalence of HIV, tuberculosis, SARS-CoV, and the current SARS-CoV-2. Smoking cessation can reduce the risk of infection [5].

Another study that was published by Michael J. Thun, M.D., *et al.*, stated that Nicotine would inhibit the antiviral responses of the human body which facilitate the spread of the virus in the human body. This study concluded that “It is emphasized that smoking is certainly a harmful factor for human health. Although nicotine has beneficial anti-inflammatory effects when used alone, due to its toxicity and addictive potential.” However, further research is recommended. Nicotine exposure would suppress the immune system in the human body, makes anti-inflammatory effects, and reduces the secretion of inflammatory an-

tibodies and cytokines, therefore reduces, and decreases the activity of the lymphocytes [6].

The findings of a study on smoking effects on adaptive immune system that was published by Shabir, Osman identified three novel variables associated with cytokine secretion variability and revealed roles for smoking in the short- and long-term regulation of immune responses. These findings have potential clinical implications for the risk of developing infections whether Bacterial or Viral infections, cancers such as breast and gastric cancers, or autoimmune diseases such as ulcerative colitis (UC) and Crohn's disease (CD). Therefore, it was concluded that smoking would compromise the ability of the body to metabolize harmful agents, potentially leading to impaired lung function. Thus, suggested that smoking can induce specific epigenetic modifications that could subsequently lead to altered immune responses. Furthermore, has shown a short-term effect of smoking on innate immune responses, and a long-term effect of smoking on adaptive immune responses. The long-term impacts are characterized by decreasing the body's ability to fight off infections instantly and over time and unveils the potential risks of chronic diseases involving inflammation [7].

Smoking has a strong impact on the inflammatory response to bacteria, but this is lost soon after quitting. However, the impact on T cell responses remains for years after [8].

#### **4. Statistics and Epidemiology**

Smoking is one of the leading causes of preventable deaths and illnesses within the USA (United States of America) in which statistics showing that approximately 480,000 people within the USA dying from smoking-related illnesses each year [9].

Smoking tobacco kills up to half the number of its users who do not quit. Smoking tobacco kills more than 8 million people yearly. An estimate of 80% of the world's 1.3 billion tobacco users live in both low- and middle-income countries [10].

Smoking significantly increases the risk of various diseases compared to non-smokers. Some of the increased risk percentages include:

- Coronary Heart Disease (CHD): 2 to 4 times higher risk [11].
- Stroke: 2 to 4 times higher risk [11].
- Lung Cancer: Men have a 25 times higher risk, and women have a 25.7 times higher risk [11].
- Chronic Obstructive Pulmonary Disease (COPD): Male smokers have a 25.61 times higher risk, and female smokers have a 22.35 times higher risk [12].
- Ischemic Heart Disease: 2.50 times higher risk for men and 2.86 times higher risk for women [12].

Additionally, smoking is associated with increased risks of other diseases such as renal failure, intestinal ischemia, hypertensive heart disease, infections, various respiratory diseases, breast cancer, and prostate cancer.

## 5. Best Recommended Practices to Emphasize for Smoking Cessation

Current best practices in smoking cessation emphasize a comprehensive approach that includes both behavioral interventions and pharmacotherapy. Summary of the key strategies might include:

### **Behavioral Interventions:**

- Counseling: For instance, in-person or over the phone through quit lines to provide support and guidance [13].
- Education: like informing about the health risks of smoking and benefits of quitting.
- Support groups: Facilitating peer support for individuals attempting to quit.

### **Pharmacotherapy:**

- Nicotine replacement therapy (NRT).
- Non-Nicotine Medications: Such as Bupropion and Varenicline which are FDA-approved to help quit smoking [14].

## 6. The Role of Public Health Policies with Smoking Cessation

Public health policies play a major and crucial role in smoking cessation efforts. They are designed to create environments that support individuals in their attempts to stop smoking and to prevent the initiation of smoking among non-smokers. Some key strategies on how public health policies contribute to smoking cessation might include:

- Regulation: For instance, creating and then implementing laws that restrict smoking in public places.
- Taxation: Increasing taxes on tobacco products to make them less affordable [15].
- Education.
- Cessation Programs: By providing access to smoking cessation programs [16].
- Insurance Coverage: By ensuring that insurance plans cover smoking cessation and treatments.
- Research and Surveillance: By supporting research on effective cessation methods.

## 7. Electronic Cigarettes

Although E-Cigarette or vaping is being advertised as a safer smoking habit than regular smoking cigarettes and a good way to induce smoking cessation. However, it has been found that E-Cigarettes or vaping have bad health impacts as much as the same of regular smoking cigarettes on both the respiratory and the cardiovascular functions [17].

E-cigarettes have been shown to impact the immune system in several ways. Studies suggest that exposure to E-Cigarette vapor can lead to impaired innate immune system, increased inflammation, and respiratory tract infections [18].

## 8. Hookahs

According to the CDC of USA, hookah has high levels of toxic agents known to cause oral, bladder, and lung cancers. Although, many users think that hookah is less harmful than regular cigarette smoking. However, hookah has many of the same harmful substances that do exist in regular cigarettes such as nicotine, tar, and heavy metals [19].

Hookah smoking, also known as waterpipe smoking, can have several adverse effects on the immune system. It exposes users to many of the same harmful compounds found in regular cigarette smoke, but often at higher levels, which can lead to more severe health effects. Some of the impacts on the immune system include increased infection risk, impaired respiratory immunity, and systemic effects [20].

## 9. Conclusions

The impact of smoking on the immune system is profound and lasting. Research reveals that smoking can influence immune responses to a similar extent as age or genetics. When our bodies encounter pathogens, immune cells release molecules called cytokines to coordinate defense mechanisms. Smoking disrupts both innate and adaptive immune mechanisms, heightening inflammatory responses and impairing immune memory cells. Even after quitting smoking, these effects persist. In which smoking leads to mixed inflammation and immunosuppression throughout the body, making it less effective at fighting infections and diseases.

A lot of studies and trials have been done on nicotine usage via smoking whether cigarettes, hookahs, or E-Cigarettes in which all resulted on the same outcomes of the bad effects and negative impacts on overall health. Thus, smoking might lead the user to be in immunocompromised status.

The impact of smoking on the immune system is a topic that requires further investigation and clinical trials. While we know that smokers tend to experience more severe infections, including respiratory diseases like COVID-19, the exact timeline for smokers to become immunocompromised remains an area of ongoing research. While we recognize the risks associated with smoking and its potential impact on immunity, precise timelines for immunocompromise in smokers require further scientific investigation.

## Conflicts of Interest

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

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