



January 2018

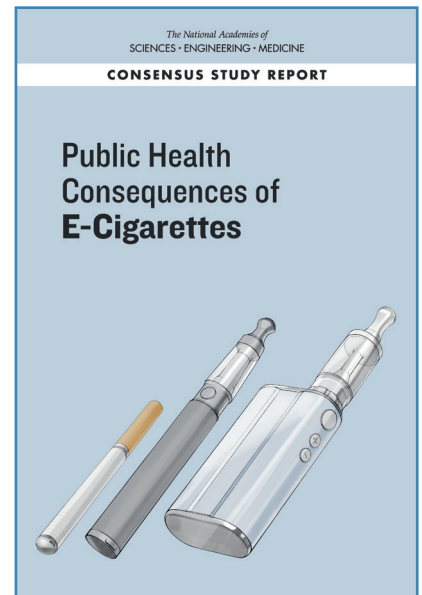
Public Health Consequences of E-Cigarettes

Millions of Americans use electronic cigarettes (e-cigarettes). Young people especially, age 17 and under, have quickly taken up their use: Substantially more young people use e-cigarettes than any other tobacco product, including traditional combustible tobacco cigarettes.

Despite their popularity, little is known about the health effects of e-cigarettes. Perceptions of potential risks and benefits of e-cigarette use vary widely among the public, users of the products, health care providers, and the public health community.

With support from the Center for Tobacco Products of the Food and Drug Administration (FDA), the National Academies of Sciences, Engineering, and Medicine convened an expert committee to conduct a critical, objective review of the scientific evidence about e-cigarettes and health. The resulting report, *Public Health Consequences of E-Cigarettes*, provides an overview of the evidence, recommends ways to improve the research, and highlights gaps that are priority focus areas for future work.

As part of its work, the committee conducted a comprehensive, in-depth review of the scientific literature around e-cigarettes, including key constituents in e-cigarettes, human health effects, initiation and cessation of combustible tobacco cigarette use, and harm reduction. The committee considered the quality of individual studies and the totality of the evidence to provide 47 structured, consistent conclusions on the strength of the evidence (categorized as conclusive, substantial, moderate, limited, insufficient, and no evidence—all defined on the next page).



CONSTITUENTS OF E-CIGARETTES

E-cigarettes contain liquids (called e-liquids), which typically contain nicotine, flavorings, and humectants (to retain moisture).

With respect to nicotine, conclusive evidence shows that exposure to nicotine from e-cigarettes is highly variable. It depends on characteristics of the products, including those of the device and e-liquids, as well as how the device is operated. Substantial evidence also shows that among experienced adult e-cigarette users, exposure to nicotine can be comparable to that from combustible tobacco cigarettes.

Most of the flavorings used in e-cigarettes are generally regarded as safe by the FDA, although these designations relate to oral consumption (flavorings used in food), and most have not been studied for safety when inhaled with an e-cigarette.

The primary humectants are propylene glycol and glycerol (also known as vegetable glycerin). Similar to flavorings, they are generally regarded as safe for ingestion, but less is known about their health effects when inhaled.

Overall, e-cigarette aerosol contains fewer numbers and lower levels of toxicants than smoke from combustible tobacco cigarettes. Nicotine exposure can mimic that found with use of combustible tobacco cigarettes, but it is highly variable. The exposure to nicotine and toxicants from the aerosolization of flavorings and humectants depends on device characteristics and how the device is used.

HEALTH EFFECTS OF E-CIGARETTES

Because e-cigarettes have only been on the U.S. market for a relatively brief time—first imported in 2006, most have entered the market much more recently—it is difficult to scientifically compare their health effects to those of combustible tobacco cigarettes, whose health effects were not fully appreciated until after decades of use. However, in contrast to long-term effects, research on short-term health effects of e-cigarettes is now available.

The committee evaluated the current state of knowledge on outcomes including dependence and abuse liability, cardiovascular diseases, cancers, respiratory diseases, oral diseases, reproductive and developmental effects, and injuries and poisonings.

Overall, the evidence reviewed by the committee suggests that e-cigarettes are not without biological effects in humans. For instance, use of e-cigarettes results in dependence on the devices, though with apparently less risk and severity than that of combustible tobacco cigarettes. Yet the implications for long-term effects on morbidity and mortality are not yet clear.

To see the full text of the committee's conclusions organized by levels of evidence and outcome, visit [nationalacademies.org/eCigHealthEffects](https://www.nationalacademies.org/eCigHealthEffects).

Levels of Evidence for Conclusions

Conclusive evidence: There are many supportive findings from good-quality controlled studies (including randomized and non-randomized controlled trials) with no credible opposing findings. A firm conclusion can be made, and the limitations to the evidence, including chance, bias, and confounding factors, can be ruled out with reasonable confidence.

Substantial evidence: There are several supportive findings from good-quality observational studies or controlled trials with few or no credible opposing findings. A firm conclusion can be made, but minor limitations, including chance, bias, and confounding factors, cannot be ruled out with reasonable confidence.

Moderate evidence: There are several supportive findings from fair-quality studies with few or no credible opposing findings. A general conclusion can be made, but limitations, including chance, bias, and confounding factors, cannot be ruled out with reasonable confidence.

Limited evidence: There are supportive findings from fair-quality studies or mixed findings with most favoring one conclusion. A conclusion can be made, but there is significant uncertainty due to chance, bias, and confounding factors.

Insufficient evidence: There are mixed findings or a single poor study. No conclusion can be made because of substantial uncertainty due to chance, bias, and confounding factors.

No available evidence: There are no available studies; health endpoint has not been studied at all. No conclusion can be made.

The net public health outcome of e-cigarette use depends on the balance between positive and negative consequences.

E-CIGARETTES AND HARM REDUCTION

FDA regulations require that tobacco products introduced to the U.S. market over the past decade must show a net public health benefit. In considering this public health effect, a product must pose less risk to users than combustible tobacco cigarettes. Additionally, if a product caused more people to start harmful tobacco use, or caused fewer people to quit tobacco use, a product would be kept off the market. So separate from the health effects of e-cigarettes, the tobacco control field must pay close attention to the effects of e-cigarettes on starting and quitting combustible tobacco products.

For youth and young adults, there is substantial evidence that e-cigarette use increases the risk of ever using combustible tobacco cigarettes. For e-cigarette users who have also ever used combustible tobacco cigarettes, there is moderate evidence that e-cigarette use increases the frequency and intensity of subsequent combustible tobacco cigarette smoking.

There is insufficient evidence from randomized controlled trials about the effectiveness of e-cigarettes as cessation aids compared to no treatment or to FDA-approved smoking cessation treatments. While the overall evidence from observational trials is mixed, there is moderate evidence from observational studies that more frequent use of e-cigarettes is associated with increased likelihood of cessation.

Overall, the evidence suggests that while e-cigarettes might cause youth who use them to transition to use of combustible tobacco products, they might also increase adult cessation of combustible tobacco cigarettes.

Completely substituting e-cigarettes for combustible tobacco cigarettes conclusively reduces a person's exposure to many toxicants and carcinogens present in combustible tobacco cigarettes and may result in

reduced adverse health outcomes in several organ systems. **Across a range of studies and outcomes, e-cigarettes appear to pose less risk to an individual than combustible tobacco cigarettes.**

To examine the possible effects of e-cigarette use at the population level, the committee used population dynamic modeling. Under the assumption that using e-cigarettes increases the net cessation rate of combustible tobacco cigarettes among adults, the modeling projects that in the short run, use of these products will generate a net public health benefit, despite the increased use of combustible tobacco products by young people. Yet in the long term (for instance, 50 years out), the public health benefit is substantially less and is even negative under some scenarios. If the products do not increase combustible tobacco cessation in adults, then with the range of assumptions the committee used, the model projects that there would be net public health harm in the short and long terms.

RESEARCH RECOMMENDATIONS

There is a great need for more evidence around the new field of e-cigarettes; research with both long- and short-term horizons is required.

The committee identified gaps in the literature in every aspect in its work and provides overarching categories of research needs and specific research suggestions within the final chapters of each of the three major sections of the report. These overarching categories include: (1) addressing gaps in substantive knowledge and (2) improving research methods and quality through protocol and methods validation and development, including the use of appropriate study design.

To download a copy of the report and read the full text of the committee's recommendations, please visit **[nationalacademies.org/eCigHealthEffects](https://www.nationalacademies.org/eCigHealthEffects)**.

Committee on the Review of the Health Effects of Electronic Nicotine Delivery Systems

David L. Eaton (Chair)

University of Washington

Anthony J. Alberg

University of South Carolina

Maciej Goniewicz

Roswell Park Comprehensive Cancer Center

Adam Leventhal

University of Southern California

José E. Manautou

University of Connecticut

Sharon McGrath-Morrow

Johns Hopkins University School of Medicine

David Mendez

University of Michigan

Richard Miech

University of Michigan

Ana Navas-Acien

Columbia University

Kent E. Pinkerton

University of California, Davis

Nancy A. Rigotti

Harvard Medical School and Massachusetts General Hospital

David A. Savitz

Brown University

Gideon St.Helen

University of California, San Francisco

CONCLUSION

Although e-cigarettes are not without risk, compared to combustible tobacco cigarettes they contain fewer toxicants; can deliver nicotine in a similar manner; show significantly less biological activity in most, but not all, in vitro, animal, and human systems; and might be useful as a cessation aid in smokers who use e-cigarettes exclusively. However, young people who begin with e-cigarettes are more likely to transition to combustible cigarette use and become smokers who are at risk to suffer the known health burdens of combustible tobacco cigarettes. The net public health outcome of e-cigarette use depends on the balance between positive and negative consequences.

More and better research is needed to help clarify whether e-cigarettes will prove to reduce harm—or induce harm—at the individual and the population levels. The approach taken by the committee to evaluate the health effects of e-cigarettes in this report is anticipated to provide a generalizable template for future evaluations of the evidence.

Study Staff and Fellow

Kathleen Stratton

Study Director

Leslie Y. Kwan

Associate Program Officer

Aimee Mead

Research Associate
(from July 2017)

Alexis Wojtowicz

Senior Program Assistant

Jorge Mendoza-Torres

Senior Research Librarian

Rebecca Morgan

Senior Research Librarian

Doris Romero

Financial Associate
(until March 2017)

Misrak Dabi

Financial Associate
(from April 2017)

Hope Hare

Administrative Assistant

Rose Marie Martinez

Senior Board Director, Board on Population Health and Public Health Practice

Andrew Merluzzi

Christine Mirzayan Science and Technology Policy Graduate Fellow

Study Sponsor

U.S. Food and Drug Administration

To read the full report, please visit
[nationalacademies.org/eCigHealthEffects](https://www.nationalacademies.org/eCigHealthEffects)

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

The nation turns to the National Academies of Sciences, Engineering, and Medicine for independent, objective advice on issues that affect people's lives worldwide.

www.national-academies.org