TECHNICAL REPORT

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

Protecting Children and Adolescents From Tobacco and Nicotine

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This technical report provides the evidence base for the accompanying tobacco clinical report and policy statement. It builds on, strengthens, and expands AAP recommendations from the previous version in 2015. Tobacco use remains the leading preventable cause of disease and death for adults in the United States. The tobacco epidemic takes a substantial toll on children's and adolescent's health, including harms because of prenatal exposure during pregnancy, secondhand and thirdhand exposure during infancy and childhood, and/or direct use during adolescence. Tobacco and nicotine use almost always starts in childhood or adolescence. Almost 40% of children aged 3 to 11 years are regularly exposed to secondhand tobacco smoke, and rates of secondhand exposure to e-cigarette aerosol have increased over the last decade.

DEFINITIONS

Tobacco Product: Any product or device that can deliver nicotine to the human brain, whether derived from tobacco or another source, except for safe and effective nicotine replacement therapies approved by the US Food and Drug Administration (FDA) for tobacco cessation. Tobacco products include, but are not limited to, e-cigarettes, cigarettes, cigars, smokeless tobacco, hookahs, pipe tobacco, heated tobacco products, and nicotine "tobacco-free" pouches.

Secondhand Smoke: Smoke emitted from a tobacco product or exhaled from a person who smokes that is inhaled by a person who does not smoke.

Thirdhand Smoke: Tobacco smoke that is absorbed onto surfaces and exposes a person who does not use tobacco to its components by direct contact and dermal absorption, ingestion, and/or off-gassing and inhalation. Thirdhand smoke may react with oxidants and other compounds in the environment to yield secondary pollutants.

abstract

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Tobacco Smoke Exposure: Tobacco smoke exposure among people who do not use tobacco, which includes both secondhand and thirdhand exposure.

E-cigarettes: Handheld devices that come in a variety of shapes and sizes. Most have a battery, a heating element, and a container to hold a solution that can contain nicotine, flavorings, and other chemicals. E-cigarettes are known by many different names. They are sometimes called e-cigs, e-hookahs, mods, pods, vapes, vape pens, tank systems, and electronic nicotine delivery systems or referred to by brand name, including Juul or Puff Bar.

Aerosol Exposure: The emissions from e-cigarettes to which people who do not use e-cigarettes are exposed, including secondhand and thirdhand exposure.

Tobacco Use Disorder: A clinical diagnosis for which treatment is within the scope of practice of pediatric providers. Moderate or severe tobacco use disorder is defined as having 4 or more symptoms that arise from tobacco use (eg, craving; withdrawal; tolerance; increasing use over time; social, occupational, or health consequences from nicotine use).

INTRODUCTION

This technical report describes the evidence base for the accompanying policy statement[1] and clinical report[2] from the American Academy of Pediatrics (AAP) on tobacco. It builds on, strengthens, and expands AAP recommendations from the 2015 technical report "Protecting Children From Tobacco, Nicotine, and Tobacco Smoke."[3] Although many key findings and evidence-based conclusions from the 2015 report remain relevant, this revision expands on and adds key conclusions based on new evidence since the last summative review. The goals of this technical report are to review the current evidence around: (1) the harms of tobacco and nicotine; and (2) clinical and policy efforts to reduce adverse outcomes from tobacco and nicotine exposure in any form—including the use of and exposure to smoke or aerosol from these products—among children and adolescents. Conclusions from evidence-based reports conducted by well-established institutions, such as the Office of the Surgeon General, any interim evidence, and data from populations traditionally underrepresented in tobacco research are summarized in this report. For this report, a broad definition for tobacco products is used to include any product that delivers nicotine to the human brain, whether derived from tobacco or another source, except for safe and effective nicotine replacement therapies approved by the FDA for smoking cessation. This broad definition acknowledges the biological mechanism by which nicotine perpetuates the harms of tobacco and nicotine use and exposure among children and adolescents.

APPROACH TO EVIDENCE REVIEW

A medical librarian conducted a search in PubMed and Medline to identify English-language literature published from 2014 through 2021 (ie, since publication of the 2015 technical report). The results from the database searches were supplemented with bibliographies of other relevant reviews, suggestions from experts, and monitoring of news and table-of-contents alerts. Ongoing surveillance was conducted by the report's authors to identify newly published studies that may affect the findings of this report.

Evidence review was conducted in Covidence.[4] Two reviewers independently reviewed abstracts and full-text articles against prespecified inclusion criteria: (1) relevance to pediatrics (defined as including study outcomes for individuals <21 years of age); and (2) high-quality study design (defined as randomized controlled clinical trials, large representative observational/epidemiologic studies, meta-analyses incorporating large representative studies with consistent results, systematic reviews, or major summative reports by respected authorities, such as the US Surgeon General). In support of the AAP Equity Agenda and acknowledging the systemic underrepresentation of many groups of children and adolescents from tobacco research, studies were reviewed relevant to pediatrics (as defined above) with data from populations traditionally underrepresented in pediatric tobacco research, including communities that have historically experienced high levels of discrimination and stigma, regardless of study design. Because of the broad nature of the topic of harms of tobacco and nicotine, emerging preclinical evidence of harms were included as relevant. Major exclusion criteria included: (1) studies funded by tobacco companies; and (2) studies from predatory journals, as defined by an updated version of Beall's list.[5] When multiple studies produced similar findings, the best quality and/or most recent are presented with reference to meta-analyses or authoritative statements (eg, reports of the Surgeon General, and US Preventive Services Task Force [USPSTF] recommendations or guidelines) when available.

GRADING EVIDENCE QUALITY

Full-text articles meeting eligibility criteria were assessed for quality. The evidence supporting the summaries of the harms of tobacco and nicotine products, as well as the clinical and policy recommendations were graded based on the Grading

of Recommendations Assessment, Development and Evaluation (GRADE) working group definitions, which consider study limitations, consistency of effect, imprecision, indirectness, and publication bias. Per the Grading of Recommendations Assessment, Development and Evaluation definitions, articles were classified into 4 quality groups:

1. High quality (further research is very unlikely to change our confidence in the estimate of effect).
2. Moderate quality (further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate).
3. Low quality (further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate).
4. Very low quality (any estimate of effect is very uncertain).[6]

Clinical and policy recommendations[1,2] were developed using the evidence-based approach as detailed by the AAP.[7,8]

KEY FINDINGS FROM LITERATURE REVIEW

Tobacco Product Use

1. Tobacco Product Use is Common Among Youth

Quality of Evidence: High

Since publication of the last technical report,[3] the landscape of tobacco product use among youth in the United States has shifted dramatically. Use of e-cigarettes increased considerably since 2015, making them the most common tobacco product used among youth. Various sources are used to capture data on tobacco use, each with slightly different definitions of tobacco product design and terminology. Similar trends have been observed across cross-sectional surveys with data on youth use, including, for example, the National Youth Tobacco Survey,[9] Monitoring the Future,[10] and the Youth Risk Behavior Surveillance system.[11]

According to the 2022 data, current use of any tobacco product was reported by 11.3% of all students, including 16.5% of high school and 4.5% of middle school students. E-cigarettes were the most used tobacco product among high school (14.1%) and middle school (3.3%) students. Among high school students, 5.2% reported current use of any combustible tobacco product. By product, current use among high school students was highest for e-cigarettes (14.1%), followed by cigars (2.8%), cigarettes (2.0%), smokeless tobacco (1.6%), hookahs (1.5%), nicotine pouches (1.4%), heated tobacco products (1.1%), and pipe tobacco (0.7%). Among middle school students, 1.6% reported current use of any combustible tobacco product. By type of product, current use among middle school students was highest for e-cigarettes (3.3%), followed by cigarettes (1.0%), smokeless tobacco (0.7%), heated tobacco products (0.7%), cigars (0.6%), hookahs (0.5%), nicotine pouches (0.5%), and pipe tobacco (0.3%).[9]

2. Tobacco Use Disproportionately Affects Youth From Communities That have Historically Experienced High Levels of Discrimination and Stigma

Quality of Evidence: High

Although overall use of combustible tobacco products has declined, tobacco use, tobacco smoke exposure, and the health harms from use and exposure continue to disproportionately affect youth from communities that have historically experienced high levels of discrimination and stigma. Among high school students, current use of any tobacco product tends to be highest among non-Hispanic Native Hawaiian/Other Pacific Islander youth and non-Hispanic American Indian/Alaska Native youth, followed by multiracial youth, non-Hispanic white youth, Hispanic youth, non-Hispanic Black youth, and Asian American youth.[12,13] Tobacco use also varies by sexual identity, with youth identifying as lesbian, gay, or bisexual reporting higher tobacco use compared with those identifying as heterosexual or uncertain sexual identity,[12] as well as gender identity, with youth identifying as transgender reporting higher tobacco use compared with their cisgender peers.[14] Further, the particular tobacco product used tends to vary by race/ethnicity. Among middle and high school students, cigars were the most common product currently used by non-Hispanic Black students, whereas e-cigarettes were the most commonly used product for all other racial/ethnic groups.[12] Among adults, cigarette smoking rates are particularly high in non-Hispanic American Indian/Alaska Native people and LGBTQ individuals.[15,16] Further, among adults, cigarette smoking rates remain high among people who are incarcerated, people of low socioeconomic status, adults whose highest level of educational attainment is a general educational development certificate, people who are uninsured and those with Medicaid insurance, adults with a disability, and people with mental illness and substance use disorders.[15,16]

These disparities in tobacco use are driven by a multitude of differences in exposure to risk and protective factors, including those related to social determinants of health, tobacco product marketing, and exposure to trauma, discrimination, and stigma within different communities. The AAP clinical report on health disparities in tobacco use and exposure details the

key factors and structural barriers that drive some youth from communities that have historically experienced high levels of discrimination and stigma to initiate and use tobacco at disproportionately high rates.[17] Several studies, for example, have identified both a greater number and larger presence of tobacco advertising in communities with a higher density of Black residents.[17,18] Additionally, the tobacco industry aggressively targets children and youth.[19,20] People who smoke often have poor access to health insurance and health care, lack access to cessation resources, and live in poverty, all of which, in addition to other factors, perpetuate tobacco use.[17] Tobacco use and exposure reinforces existing health disparities, and these health disparities perpetuate tobacco use, creating a cycle of intergenerational tobacco use and poor health.[17]

3. As the Tobacco Product Landscape Diversifies, Multiple Tobacco Product Use is Common Among Youth

Quality of Evidence: High

In addition to the dramatic rise of e-cigarettes since publication of the 2015 technical report, the tobacco product landscape continues to diversify. Tobacco products include combustible tobacco products (including cigarettes, cigars, hookahs, pipe tobacco), smokeless tobacco products, and new and emerging products such as e-cigarettes, heated tobacco products, and nicotine pouches. Dual and polytobacco use, defined as the use of 2 or more tobacco products, respectively, is common among youth.[11,12] According to data published from 2020, 8.2% of all high school students (34.7% of high school students who use any tobacco products) and 2.8% of all middle school students (41.8% of middle school students who use any tobacco products) reported current use of multiple tobacco products.[12]

4. E-Cigarette Use Among Adolescents Increases the Risk of Traditional Cigarette Smoking

Quality of Evidence: High

Strong and consistent evidence finds that children and adolescents who use e-cigarettes are significantly more likely to go on to use traditional cigarettes. The National Academies of Sciences, Engineering, and Medicine report found that, in youth and young adults, there is substantial evidence that e-cigarette use increases risk of ever using combustible tobacco and moderate evidence that e-cigarette use increases the frequency and intensity of subsequent cigarette smoking.[21] The AAP policy statement "E-Cigarettes and Similar Devices" details the links between e-cigarette companies' coordinated, targeted advertising to youth and youth e-cigarette initiation. That report also highlights the substantial and consistent evidence from several separate, well-designed longitudinal studies: adolescents and young adults who use e-cigarettes, compared with those who do not, are at higher risk of transitioning to traditional cigarettes.[22] Multiple systematic reviews and meta-analyses have found e-cigarette use is associated with an increased risk of subsequent cigarette smoking initiation and current cigarette smoking in young people.[23–26]

Tobacco and Nicotine Use

5. Tobacco Use Disorder Almost Always Develops Before 18 Years of Age

Quality of Evidence: High

Tobacco use is a pediatric epidemic, as tobacco use disorder almost always starts in childhood or adolescence. Among adults who smoke cigarettes daily, nearly 90% first started using cigarettes before 18 years of age, with 99% of first use by 26 years of age.[19] The 2012 Surgeon General's report highlighted several key social–environmental factors that support the onset of nicotine addiction during childhood or adolescence. Children and adolescents are developmentally vulnerable to social and environmental influences to use tobacco. This includes pervasive tobacco product marketing that targets youth and has been shown to "cause the onset and continuation of smoking among adolescents and young adults," as well as family and peer modeling of tobacco use.[19]

6. Nicotine is a Highly Addictive Drug That Can Have Lasting Damaging Effects on Adolescent Brain Development and Has Been Linked to a Variety of Adverse Health Outcomes

Quality of Evidence: High

Nicotine is a highly addictive substance. The 2010 Surgeon General's report concluded, "Nicotine is the key chemical compound that causes and sustains the powerful addicting effects of commercial tobacco products."[27] The AAP technical report "Nicotine and Tobacco as Substances of Abuse in Children and Adolescents" reviewed the physiologic characteristics, neurobiology, metabolism, pharmacogenetics, and health effects of nicotine, highlighting how the addictive nature of nicotine is responsible for its widespread use and difficulty with quitting.[28] The report summarized the particularly addictive nature of nicotine when used by adolescents. Early symptoms of tobacco use disorder, such as wanting to smoke or craving a cigarette, can emerge even after the adolescent smokes their first cigarette.[29] This nicotine craving and withdrawal partially drives the progression from intermittent to daily smoking, which dramatically increases likelihood of developing a lifelong tobacco use disorder. The earlier in childhood an individual uses nicotine-containing products, the stronger the likelihood of developing tobacco use disorder and the more difficult it is to quit.[19]

Further, nicotine can have lasting damaging effects on adolescent brain development and has been linked to a variety of adverse health outcomes. The 2014 Surgeon General's report concluded: "The evidence is suggestive that nicotine exposure during adolescence, a critical window for brain development, may have lasting adverse consequences for brain development."[30] Nicotine can change adolescent brain cell activity[31] in the parts of the brain responsible for attention, learning, and memory. As such, nicotine exposure among youth is linked to reduced impulse control, deficits in attention and cognition with corresponding increased risk of attention-deficit/hyperactivity disorder (ADHD), and increased risk of mood disorders, including anxiety and depression.[32] Nicotine also can negatively impact the prefrontal cortex, the brain area responsible for executive function, leading to long-term effects on the ability to make decisions.[33] Nicotine may also increase the risk of developing other substance use disorders, such as cocaine use disorder.[34] Although there are few existing human studies examining the effects of pure nicotine exposure, preclinical and clinical studies indicate that nicotine use alone has the potential to cause developmental abnormalities, harm childhood health, and addict a new generation of adolescents and young adults.[35]

Tobacco Use-Related Mortality and Morbidity

7. Tobacco Use Leads to Substantial Death and Disease

Quality of Evidence: High

Tobacco use by youth and young adults has well-documented, severe adverse health consequences. This evidence has been summarized in multiple reports of the Surgeon General from 1964 onward.[19,27,30,36,37] Tobacco use remains one of the leading preventable causes of disease and death in the United States.[38] Cigarette smoking causes about 1 of every 5 deaths in the United States each year, or more than 480 000 deaths annually (including deaths from secondhand smoke [SHS] exposure).[30] Cigarette smoking causes premature death, with the average person who smokes dying 10 years earlier than their nonsmoking peers.[30] The landmark 40-year prospective follow-up study of nearly 35 000 male British physicians found that nearly half of all people who regularly smoked cigarettes died as a result of their tobacco use disorder.[39] Quitting smoking before 40 years of age reduces the risk of dying from smoking-related disease by about 90%.[40]

8. Youth Use of Tobacco Products in Any Form is Unsafe

Quality of Evidence: High

Youth use of any tobacco products is unsafe, regardless of the form of use.[30] As summarized in multiple Surgeon General's reports, cigarette smoking harms nearly every organ in the body.[30,37] Smokeless tobacco product use causes cancers of the mouth and is associated with other diseases of the mouth.[30] Numerous toxicants and carcinogens have been found in e-cigarette aerosol and solutions and in the bodies of adolescents who use e-cigarettes.[22,41,42] E-cigarette use is associated with increased risk of asthma and chronic obstructive pulmonary disease[43] and cardiovascular disease.[44] E-cigarettes were implicated in a nationwide outbreak of severe lung injury cases, referred to as e-cigarette or vaping product use-associated lung injury.[45] More than 2800 hospitalizations with 68 deaths were reported to the Centers for Disease Control and Prevention (CDC) across the United States as of February 2020, after which the CDC stopped collecting data. The median age of patients was 24 years, with 15% of patients younger than 18 years.[46] Although most pediatric patients improved with supportive care, in the minority of cases, the illness progressed to lung destruction, resulting in death[46,47] or, in at least one pediatric case, the need for lung transplantation.[48] The emissions from heated tobacco products contain many of the same harmful constituents as cigarette smoke, such as volatile organic compounds, polycyclic aromatic hydrocarbons, and carbon monoxide,[49] which have been shown through extensive research to cause serious harms to human health.[30] Adolescent tobacco and/or nicotine use may increase risk for other drug use. Cohort studies reveal that tobacco use often precedes the use of other drugs in adolescents and that tobacco use during adolescence is a risk factor for future use of other drugs and alcohol.[19]

Tobacco and Nicotine: Public Health Burden

9. Tobacco Use Creates a Substantial Economic Burden for the United States

Quality of Evidence: High

Smoking-related illness in the United States costs more than $300 billion each year, which includes nearly $170 billion for direct medical care of adults; more than $156 billion in lost productivity because of premature death; and, within that, $5.6 billion in lost productivity attributable to SHS exposure.[30,50] Further, tobacco use leads to a substantial burden for the armed services. According to a 2009 Institute of Medicine report, "Every year, tobacco use leads to unnecessary compromises in the readiness of our troops and costs the Department of Defense millions of dollars in preventable health care costs."[51]

10. Tobacco Use Disorder Is a Treatable Chronic Illness

Quality of Evidence: High

Since publication of the 2015 technical report, new reports have summarized the expanding scientific base in support of quitting smoking,

including the 2020 Surgeon General's report on smoking cessation[52] and the 2021 final recommendation statement from the USPSTF on tobacco smoking cessation in adults, including pregnant persons.[53] The 2020 Surgeon General's report emphasized several major conclusions related to smoking cessation. First, smoking cessation is beneficial at any age, reducing the risk of premature death, adding as much as a decade to life expectancy while also reducing the risk of many adverse health effects. Second, most adults who smoke want to and attempt to quit each year, but less than one-third use FDA-approved cessation medications or behavioral counseling to support these attempts to quit—a major opportunity for health care intervention. Finally, there are many cost-effective cessation strategies with strong evidence showing they increase the likelihood of successfully quitting smoking, especially when used in combination (eg, nicotine replacement therapy [NRT] plus the Quitline).[52]

For the recent 2021 USPSTF report, the task force commissioned a systematic review to evaluate the benefits and harms of primary care interventions on tobacco use treatment in adults, including pregnant persons. The USPSTF reviewed both evidence on the benefits of pharmacotherapy from 4 systematic reviews that reported smoking cessation at 6 months or more, as well as evidence on the benefits of behavioral counseling interventions on tobacco use cessation in adults, primarily from 20 systematic reviews that covered approximately 830 randomized controlled trials and more than 500 000 participants.[54] Based on the review of the existing literature, the USPSTF made the following recommendations: Clinicians should "ask all adults about tobacco use, advise them to stop using tobacco, and provide behavioral interventions and FDA-approved pharmacotherapy for cessation to nonpregnant adults who use tobacco" (receiving an "A recommendation," meaning there is high certainty that the net benefit is substantial); and, clinicians should "ask all pregnant persons about tobacco use, advise them to stop using tobacco, and provide behavioral interventions for cessation to pregnant persons who use tobacco (A recommendation)" but the "current evidence is insufficient to assess the balance of benefits and harms of pharmacotherapy interventions for tobacco cessation in pregnant persons."[53]

Current pharmacotherapy approved by the FDA for tobacco use treatment in adults are NRT (including nicotine transdermal patches, gum, lozenges, inhalers, or nasal spray), bupropion hydrochloride sustained-release, and varenicline.[55] All 3 types of pharmacotherapy increase tobacco smoking cessation rates. Based on a smaller number of studies, varenicline appears to be more effective than NRT or bupropion sustained-release. Using a combination of NRT products (typically a long-acting therapy such as the patch with a short-acting therapy such as the gum) has been found to be more effective than using a single form of NRT.[54] Further, a 2019 Cochrane review examined the effectiveness and safety of different forms, deliveries, doses, durations, and schedules of NRT for achieving long-term smoking cessation compared with one another.[23,56] There were several practice-relevant highlights from that review. The authors identified high-certainty evidence that combination NRT (fast-acting form plus patch) results in higher long-term quit rates among adults than single form (relative risk [RR], 1.25; 95% confidence interval [CI], 1.15–1.36; 14 studies; 11 356 participants). For dosing, the review identified moderate-certainty evidence that 21-mg (24-hour) patches are more effective than 14-mg patches (RR, 1.48; 95% CI, 1.06–2.08; 1 study; 537 participants) and 4-mg gum is more effective than the 2-mg form (RR, 1.43; 95% CI, 1.12–1.83; 5 studies; 856 participants). Further, there was moderate-certainty evidence that initiation of NRT before the quit date or stopping smoking (termed "preloading") improves the effectiveness of treatment compared with using it from the quit day onward (RR, 1.25; 95% CI, 1.08–1.44; 9 studies; 4395 participants). Finally, although there is high variability in how safety data are measured and reported, evidence suggests NRT has few serious side effects and is well tolerated.[31,56] More information on dosing regimens is available in the package inserts of individual medications or in the 2020 Surgeon General's report on smoking cessation.[52]

Tobacco Smoke and Aerosol Exposure-Related Morbidity

11. Secondhand Tobacco Smoke Exposure is Common Among Children in the United States

Quality of Evidence: High

According to nationally representative data collected between 2013 and 2014, 37.9% of children 3 to 11 years of age showed signs of SHS inhalation.[57] This finding is based on questionnaire and laboratory testing data, including serum cotinine, a measure of recent nicotine exposure, as collected through the National Health and Nutrition Examination Survey and analyzed by the CDC.[58]

Although the prevalence of SHS exposure among people in the United States who do not smoke has declined substantially over the last 30 to 40 years, an estimated 1 in 4 people who do not smoke, or approximately 58 million individuals, are still regularly exposed. Significant disparities in exposure exist across population groups. In addition to the high rates of exposure among children, exposure prevalence is as follows: non-Hispanic Black people: 50.3%; people who had less than a high school education: 30.7%; people who were living in poverty: 47.9%; people living in rental housing: 38.6%; people living with someone who smoked inside the home: 73.0%.[57] Parents and caregivers with tobacco use disorder are important sources of children's SHS exposure. The home is the place where children are most exposed to SHS,[59–61] and children who live in homes where smoking is allowed have higher levels of cotinine than children who live in homes where smoking is not allowed.[60]

12. Tobacco Smoke/Aerosol Exposure Harms Children

Quality of Evidence: High

There is no risk-free level of tobacco exposure. The substantial harm of tobacco smoke exposure for fetuses, infants, and children has been extensively documented through multiple reports of the Surgeon General.[30,59] Because nicotine and other tobacco toxins cross the placenta, children can be harmed from exposure to tobacco toxins beginning in utero. This exposure can be both from the pregnant person's tobacco product use, as well as their exposure (via inhalation or absorption) to the tobacco smoke of others. Children are harmed from SHS exposure by breathing in the smoke emitted by others who are using combustible tobacco products. Numerous health problems in infants and children related to SHS exposure, including more frequent and severe asthma attacks, respiratory infections, ear infections, and sudden infant death syndrome (SIDS), are detailed below.[30] Additionally, tobacco use/nicotine exposure can negatively impact the breastfeeding infant and child. Tobacco use is associated with decreased milk volume production, lower milk fat concentration, and overall shorter breastfeeding duration.[62–64]

The aerosol produced by e-cigarettes contains many of the same toxins identified as harmful to human health as identified in secondhand smoke. Both the National Academies of Sciences, Engineering, and Medicine report on e-cigarettes and the 2016 Surgeon General's report on e-cigarettes concluded that this aerosol contains potentially harmful compounds, including nicotine, volatile organic compounds, heavy metals, and ultrafine particulates.[21,41] People can be exposed to these compounds and particulates through inhalation, ingestion, or dermal contact with aerosols exhaled into the environment.[41] Based on this evidence, the Surgeon General's report recommended prohibiting e-cigarette use in enclosed areas to avoid probable harm because of secondhand and thirdhand aerosol exposure.

Thirdhand smoke is the ultrafine particulate matter and residue left behind in indoor environments after tobacco combustion.[65] Its components include nicotine, tobacco-specific carcinogens, and other toxicants.[66,67] The toxicants from e-cigarette devices are similar to toxicants in combusted tobacco.[68] Children can absorb, ingest, and inhale these substances. Young children may have greater exposure because toddlers commonly explore by placing objects in their mouth. An analysis of house dust samples collected from private homes of individuals who smoke in northeastern Spain found tobacco-related carcinogens in the dust at levels sufficient to increase the risk of cancer.[69] Hand nicotine exposure in children of parents who smoke is associated with increased risk of respiratory illnesses.[61] Further, although underexplored in medical settings, emerging evidence suggests a large percentage of infants in NICUs have measures of thirdhand smoke exposure, despite hospital prohibitions on tobacco and/or nicotine use.[70]

13. Tobacco Exposure Harms the Fetus

Quality of Evidence: High

Since the 1964 Surgeon General's report, cigarette smoking by pregnant people has been causally linked to clear harm to the fetus.[36] Research continues to identify new diseases and harms caused by smoking during pregnancy in the fetus, expanded on in the 2014 Surgeon General's report.[30] Cigarette use before and/or during pregnancy remains a major cause of fetal and infant morbidity and mortality. Smoking by pregnant people causes preterm delivery and fetal growth restriction, placenta previa, placental abruption, orofacial clefts, and ectopic pregnancy. Evidence is suggestive of a causal relationship with clubfoot, cryptorchidism, gastroschisis, and some types of congenital heart defects. Additionally, smoking by pregnant people has been associated with stillbirth and spontaneous abortion. Nicotine plays a key role in mediating and likely causing these adverse effects on fetal and reproductive health, on the basis of experimental research and pharmacologic understanding.[30] In a 2019 systematic review, the risk of having a male infant with

cryptorchidism was significantly increased for pregnant people who smoked during pregnancy compared with those who did not smoke (pooled crude OR, 1.18; 95% CI, 1.12–1.24; $P < .00001$).[71] Although evidence is still emerging, e-cigarette use during pregnancy is associated with adverse birth outcomes, including low birth weight and preterm birth.[72]

14. Tobacco Smoke Exposure Increases Infant Mortality

Quality of Evidence: High

Tobacco smoke exposure increases an infant's risk of SIDS and sudden unexplained infant death (SUID).[59] SIDS/SUID is the leading cause of postnatal infant mortality.[73] Tobacco use during pregnancy (prenatal exposure) or SHS exposure after birth (postnatal exposure) both contribute to increased risk.[30,59] The 2014 Surgeon General's report determined that more than 1000 perinatal deaths per year are attributable to smoking or approximately 6% of prenatal condition deaths and 17% of all cases of SIDS/SUID.[30] Chemicals in SHS appear to affect key regulatory brain pathways that interfere with regulation of infants' breathing, and infants who die of SIDS/SUID have higher concentrations of nicotine in their lungs and higher levels of cotinine than infants who die of other causes.[30,59] Further, there is likely a dose-dependent effect of smoking on SUID, as a retrospective, cross-sectional study of 20 685 463 births and 19 127 SUID cases found that SUID risk more than doubled (adjusted odds ratio [aOR], 2.44; 95% CI, 2.31–2.57) with any smoking during pregnancy (compared with no smoking), increased twofold between no smoking and smoking 1 cigarette daily throughout pregnancy, and increased linearly with each additional cigarette smoked per day, increasing the odds by 0.07 for each cigarette from 1 to 20.[74]

15. Tobacco Smoke Exposure Increases Asthma Prevalence and Severity

Quality of Evidence: High

Tobacco smoke exposure increases the risk of asthma, wheezing, and asthma exacerbations in children. Parental smoking causes significant respiratory symptoms (including cough, phlegm, and breathlessness), onset of wheeze illnesses in early childhood, and asthma among school-aged children.[59] A 2015 meta-analysis of 25 studies including approximately 140 000 children of the effects of SHS exposure on asthma morbidity and health care utilization in children found SHS exposure was significantly associated with hospitalizations (OR, 1.85; 95% CI, 1.20–2.86; $P = .01$), emergency department or urgent care visits (OR, 1.66; 95% CI, 1.02–2.69; $P = .04$), and wheeze symptoms (OR, 1.32; 95% CI, 1.24–1.41; $P < .001$).[75] Among children 1 to 16 years of age hospitalized for asthma, having detectable salivary cotinine levels was associated with increased odds of readmission within 12 months (aOR, 2.35; 95% CI, 1.22–4.55).[76]

16. The Effects of Tobacco Smoke Exposure on Risk of Asthma Begin in Utero

Quality of Evidence: High

Prenatal tobacco smoke exposure adversely affects lung development, and these effects may have consequences that last beyond childhood.[30,37,59] Animal models consistently identify nicotine as the potential primary mediator of many of the adverse effects of maternal smoking on fetal lung development.[30] A meta-analysis of 79 prospective epidemiologic studies published between 1997 and February 2011 assessed the association between tobacco smoke exposure and the incidence of wheeze or asthma in childhood; it found that prenatal maternal smoking and household SHS exposure were associated with an increased risk of asthma.[77] In a cohort of mothers and their children prospectively followed up from pregnancy through the first 4 years of the child's life, exposure to maternal smoking when in utero, as well as SHS exposure after birth were associated with increased risk for wheezing at 2 to 4 years of age.[78] Smoking during pregnancy has persistent effects on lung function and asthma into adolescence, as a prospective cohort study of children from birth to 14 years of age found an association between maternal smoking and current asthma, current wheeze, and exercise-induced wheeze (OR, 1.84; 95% CI, 1.16–2.92; OR, 1.77; 95% CI, 1.14–2.75; and OR, 2.29; 95% CI, 1.37–3.85, respectively).[79] Further, smoking during pregnancy may make asthma more difficult to manage, as data from the Childhood Asthma Management Program study found in utero tobacco smoke exposure markedly attenuated the benefit of inhaled corticosteroid response among children 5 to 12 years of age with persistent asthma.[80]

17. Tobacco Smoke Exposure Increases Both the Risk and Severity of Bronchiolitis in Children

Quality of Evidence: High

In utero and SHS exposure of children leads to more severe episodes of bronchiolitis. Smoking by parents slows lung growth and causes respiratory symptoms and lower respiratory tract illnesses in their infants and children.[59] A study in Liverpool, United Kingdom, of 378 infants hospitalized for bronchiolitis, of whom 299 (79%)

had respiratory syncytial virus (RSV) infection, found that having a household member who smoked tobacco increased the odds of needing supplemental oxygen and needing mechanical ventilation during the hospitalization (OR, 2.45; 95% CI, 1.60–3.74; and OR, 5.49; 95% CI, 2.78–10.83, respectively).[81] A systematic literature review of studies assessing the effect of tobacco smoke exposure on RSV bronchiolitis in children aged younger than 5 years identified 30 relevant articles, finding a consistent relationship between exposure and increased risk of hospitalization for RSV-attributable lower respiratory tract infection and increased severity of illness among hospitalized children.[82]

18. Tobacco Smoke Exposure Increases Risk for and Severity of Other Respiratory Illnesses in Children

Quality of Evidence: High

SHS exposure increases the risk of influenza, pneumonia, and acute respiratory illnesses in infants and children, with the relationship being so strong that the evidence is sufficient to infer a causal relationship.[59] A systematic review and meta-analysis of the relationship between SHS exposure and lower respiratory tract infection in infants and children 2 years and younger identified 60 studies that found that smoking by any household member, paternal smoking, maternal prenatal smoking, and maternal postnatal smoking all increased the risk of an infant's lower respiratory tract infection (OR, 1.54; 95% CI, 1.40–1.69; OR, 1.22; 95% CI, 1.10–1.35; OR, 1.58; 95% CI, 1.45–1.73; and OR, 1.24; 95% CI, 1.11–1.38).[83] Further, a population-based, large-scale, cross-sectional survey in Vietnam of approximately 25 000 households with a child younger than 5 years found that having 1 or more household members who smoked was associated with an increased risk of hospitalization for pneumonia in the previous 12 months (aOR, 1.55; 95% CI, 1.25–1.92).[84] Finally, a study of 117 children younger than 15 years hospitalized for influenza found that the risk of ICU admission and length of stay were greater among children with a history of SHS exposure (aOR, 4.7; 95% CI, 1.4–18.5; adjusted incidence rate ratio, 1.7; 95% CI, 1.2–2.3, respectively).[85]

19. Tobacco Smoke Exposure Increases the Risk of Middle Ear Disease

Quality of Evidence: High

SHS exposure from parental smoking causes middle ear disease in children, including acute and recurrent otitis media and chronic middle ear effusion.[59] According to the AAP, approximately 5 million acute otitis media (AOM) cases are diagnosed annually in the United States, resulting in more than 10 million annual antibiotic prescriptions.[86] AOM is the most common condition treated with antibiotics, and increasing incidence of antibiotic resistance among the organisms responsible for AOM is a cause for concern. Giving a sense of the scope of the problem, a meta-analysis found that maternal postnatal smoking (20 studies) and household smoking (49 studies) increased the risk for otitis media (OR, 1.62; 95% CI, 1.33–1.97; and OR, 1.37; 95% CI, 1.25–1.50, respectively).[87]

20. Tobacco Smoke Exposure Increases the Risk of Learning and Neurobehavioral Problems in Children

Quality of Evidence: High

The 2014 Surgeon General's report concluded that "nicotine exposure during fetal development, a critical window for brain development, has lasting adverse consequences for brain development," and that evidence was suggestive of "a causal relationship between maternal prenatal smoking and disruptive behavioral disorders, and ADHD in particular, among children."[30] A meta-analysis exploring the association between maternal smoking during pregnancy and the occurrence of ADHD in offspring found that smoking during pregnancy increased the risk of ADHD in offspring (OR, 1.60; 95% CI, 1.45–1.76), with greater risk for children whose mothers' cigarette use was defined as heavy (OR, 1.75; 95% CI, 1.51–2.02) compared with mothers whose cigarette use was defined as light (OR, 1.54; 95% CI, 1.40–1.70).[88] A study in Finland of administrative data on 175 869 children born 1987 through 1989 found that maternal smoking increased the risk of having a psychiatric diagnosis through 18 years of age, controlling for maternal psychiatric diagnosis and child's sex assigned at birth.[89] A birth cohort study in Australia followed children from their first prenatal visits through 14 years of age assessing smoking and academic performance, finding low academic achievement was more common in those whose mothers had smoked during pregnancy, although effect sizes were small.[90] Further, a systematic review examining the association between prenatal or postnatal SHS exposure and cognitive function in children and adolescents found that prenatal SHS exposure was inversely associated with neurodevelopmental outcomes in young children, postnatal SHS exposure was associated with poor academic achievement and neurocognitive performance in older children and adolescents, and any SHS exposure was associated with an increased risk of neurodevelopmental delay.[91]

21. Tobacco Smoke Exposure Increases the Risk of Preclinical Atherosclerosis in Children

Quality of Evidence: High

SHS exposure in children is associated with measures of preclinical atherosclerosis and other measures of increased cardiovascular disease risk. A prospective cohort study of approximately 500 children in Finland prospectively followed the children with serum cotinine concentrations measured annually between 8 and 13 years of age followed by cardiovascular assessment at age 13.[92] The study found that frequent exposure to environmental tobacco smoke is associated with increased carotid and abdominal aortic intima-media thickness and increased apolipoprotein B levels among the healthy 13-year-olds. Similar results were found in a study of 16-year-old male adolescents[93] and in a case-control study of healthy young adults.[94] Soluble intercellular adhesion molecule 1 is a measure of endothelial stress, and hair cotinine is a biomarker of tobacco smoke exposure. In a cross-sectional sample of children 9 to 18 years of age in Ohio, hair cotinine concentrations were positively correlated with levels.[95]

22. Tobacco Smoke Exposure Increases the Risk of Childhood Cancers

Quality of Evidence: Moderate

Prenatal and postnatal exposure to SHS is associated with increased risk of childhood cancer, including leukemia, lymphoma, and brain cancers.[59] A meta-analysis examining the association between maternal smoking and early life cancers identified 62 original studies covering 24 243 cancer cases published between 1982 and 2015, finding a small increased risk of brain and central nervous system tumors but not leukemia or lymphomas.[96] A meta-analysis of 17 case-control studies investigating the association between paternal smoking before conception and during pregnancy found a small but statistically significant increased risk of childhood acute lymphoblastic leukemia.[97] Finally, tobacco-specific chemicals known to cause lung cancer in humans have been detected in the urine of children who have a household member who smokes.[98]

23. In Utero Tobacco Smoke Exposure Increases the Risk of Having Overweight in Childhood or Adolescence

Quality of Evidence: Low

Both SHS exposure of the pregnant person during pregnancy and active parent smoking are associated with increased risk of overweight in their children. A meta-analysis published in 2012 to determine risk factors for childhood overweight that can be identified during the first year of life identified 7 relevant studies, finding that, for children of a parent who smoked during pregnancy, there was an increased odds of childhood overweight (aOR, 1.47; 95% CI, 1.26–1.73).[99] A retrospective cohort study of 1366 fourth-grade students in Japan found that those whose parent smoked during pregnancy had a higher mean ± SD. BMI (17.2 ± 2.7 vs 16.9 ± 2.5; $P = .016$) when assessed at 9 to 10 years of age.[100] The Millennium Cohort Study, which prospectively followed 18 296 healthy term infants in the United Kingdom, found that smoking during pregnancy was associated with an increased odds of the child having overweight at 3 years of age (aOR, 1.33; 95% CI, 1.15–1.55).[101]

CONCLUSIONS

Tobacco use almost always starts in childhood or adolescence. The tobacco epidemic takes a substantial toll on the health of all pediatric populations, including infants, children, adolescents, and young adults, and the harm begins in utero. Actions by pediatricians can help to reduce children's risk of developing tobacco use disorder and reduce children's involuntary tobacco smoke exposure.[2] Public policy actions to protect children from tobacco have proven effective in reducing harm.[1] Effective public health approaches need to be both extended to include e-cigarettes, similar devices, and other and emerging tobacco products and expanded to reduce the toll that the tobacco epidemic takes on our children and youth.

For further reading and a summary of AAP clinical reports, policy statements, and other resources for tobacco and e-cigarettes, see Table 1.

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TABLE 1 AAP Policy Statements and Other Resources for Tobacco and E-Cigarettes

Resources for Decreasing Tobacco Exposure at the Individual Practice Level	Evidence Base for Tobacco Control	E-Cigarette and Vaping Resources	Advocacy and Policy Resources
"Protecting Children From Tobacco, Nicotine, and Tobacco Smoke" (AAP clinical report)	"Protecting Children and Adolescents From Tobacco and Nicotine" (AAP technical report)	"E-cigarettes and Similar Devices" (AAP policy statement)	"Protecting Children and Adolescents From Tobacco and Nicotine" (AAP policy statement)
CEASE Resources (Massachusetts General Hospital Web site; www.massgeneral.org/children/cease-tobacco)		Vaping, JUUL, and E-Cigarettes Presentation Toolkit (Julius B. Richmond Center of Excellence; www.aap.org/en/patient-care/tobacco-control-and-prevention/e-cigarettes-and-vaping/vaping-juul-and-e-cigarettes-presentation-toolkit/)	"Health Disparities in Tobacco Use and Exposure: A Structural Competency Approach" (AAP clinical report)
Pediatric Environmental Health (AAP policy manual)			Tobacco Prevention Policy Tool (Julius B. Richmond Center of Excellence; www.aap.org/en/patient-care/tobacco-control-and-prevention/policy-and-advocacy/tobacco-prevention-policy-tool/)
"Substance Use Screening, Brief Intervention, and Referral to Treatment" (AAP clinical report)			Tobacco Education Resources for Kids & Teens (HealthyChildren.org)
Tobacco Use: Considerations for Clinicians Resource (www.aap.org/cessation)			

ABBREVIATIONS

AAP: American Academy of Pediatrics
ADHD: attention-deficit/hyperactivity disorder
AOM: acute otitis media
aOR: adjusted odds ratio
CDC: Centers for Disease Control and Prevention
CI: confidence interval
FDA: US Food and Drug Administration
NRT: nicotine replacement therapy
RR: relative risk
RSV: respiratory syncytial virus
SHS: secondhand smoke
SIDS: sudden infant death syndrome
SUID: sudden unexplained infant death
USPSTF: US Preventive Services Task Force

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