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Guidance for the Clinical Management of Thirdhand Smoke Exposure in the Child Health Care Setting

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Abstract

Objective—To explain the concept of thirdhand smoke and how it can be used to protect the health of children and improve delivery of tobacco control interventions for parents in the child health care setting.

Methods—Review of the literature and descriptive report.

Results—The thirdhand smoke concept has been used in the CEASE intervention to improve the delivery of tobacco control counseling and services to parents. Materials and techniques have been developed for the child health care setting that use the concept of thirdhand smoke. Scientific findings demonstrate that thirdhand smoke exposure is harmful and establishes the need for clinicians to communicate the cessation imperative: the only way to protect non-smoking household members from thirdhand smoke is for all household smokers to quit smoking completely. As the scientific knowledge of thirdhand smoke increases, advocates will likely rely on it to encourage completely smoke-free places.

Conclusion—Recent scientific studies on thirdhand smoke are impelling further research on the topic, spurring the creation of tobacco control policies to protect people from thirdhand smoke and stimulating improvements to the delivery of tobacco control counseling and services to parents in child health care settings.

Keywords

thirdhand smoke; smoking; tobacco; indoor air quality; smoking cessation; pediatrics

Introduction

While “thirdhand smoke” may be a relatively new term, it is rooted in an old concept – the particulate matter and residue from tobacco smoke left behind after tobacco is burned. In

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1953, Dr. Ernest Wynder and his colleagues from the Washington University School of Medicine in St. Louis showed that condensate made from the residue of cigarette smoke causes cancer [1]. This residue left behind by burning cigarettes is now known as thirdhand smoke [2]. Dr. Wynder used acetone to rinse the leftover tobacco smoke residue from a smoking chamber where he had burned cigarettes. He then painted the solution of acetone and thirdhand smoke residue onto the backs of mice. The results of Dr. Wynder's study demonstrated that exposed mice developed cancerous skin lesions, whereas mice exposed to the acetone alone did not display skin lesions. Dr. Wynder sounded an alarm bell in his manuscript when he wrote, “Such studies, in view of the corollary clinical data relating smoking to various types of cancer, appear urgent. They may result not only in furthering our knowledge of carcinogenesis, but in promoting some practical aspects of cancer prevention [1].”

Decades of research has been conducted since Dr. Wynder's discovery to definitively conclude that smoking tobacco and exposure to secondhand tobacco smoke is harmful to human health. It is estimated that 480,000 annual premature deaths in the United States alone are attributable to smoking and exposure to secondhand smoke [3]. The World Health Organization estimates that worldwide tobacco use is responsible for more than 7 million deaths per year with 890,000 of those deaths caused by second-hand smoke exposure of nonsmokers [4]. Epidemiological evidence of the harm posed by tobacco has spurred the U.S Surgeon General to conclude that there is no risk-free level of exposure to tobacco smoke [5]. Despite the overwhelming evidence implicating tobacco as the cause of an unprecedented amount of disease resulting from the use of a consumer product, only recently has a dedicated research agenda been pursued to study what Dr. Wynder urgently called for back in 1953: further exploration of the health effects of thirdhand tobacco smoke.

The term “thirdhand smoke” was first coined in 2006 by researchers with the Clinical Effort Against Secondhand Smoke Exposure (CEASE) program at Massachusetts General Hospital in Boston, MA [6], and recent research has begun to shed considerable light on the topic. In 2011, a research consortium of scientists funded by the Tobacco-Related Disease Research Program [7] in California was set up to conduct pioneering research on the characterization, exposure and health effects of thirdhand tobacco smoke [8]. Research findings from this consortium and other scientists from around the world are quickly expanding and disseminating knowledge on this important topic.

While the research on thirdhand smoke is ongoing, this paper summarizes the current literature most relevant to the pediatric population and outlines clinical and policy recommendations to protect children and families from the harms of exposure to thirdhand smoke.

What Is Thirdhand Smoke and How Is It Different from Secondhand Smoke?

Thirdhand smoke is a result of combusted tobacco, most often from smoking cigarettes, pipes, cigars, or cigarillos. Thirdhand smoke remains on surfaces and in dust for a longtime after smoking happens, reacts with oxidants and other compounds to form secondary pollutants, and is re-emitted as a gas and/or resuspended when particles are disturbed and go

back into the air where they can be inhaled [9]. One dramatic example of how thirdhand smoke can remain on surfaces long after secondhand smoke dissipates was discovered on the ornate constellation ceiling in the main concourse of the Grand Central Terminal in New York City. According to Sam Roberts, a correspondent for the *New York Times* and the author of a book about the historic train station, the dark residue that accumulated on the concourse ceiling over decades and was originally believed to be the result of soot from train engines was primarily residue from tobacco smoke [10–12]. It wasn't until a restoration in the 1990s when workers scrubbed the tar and nicotine residue from the ceiling could the elaborate design of the zodiac signs and constellations be seen again [13]. A similar process takes place inside homes, where smoke residue accumulates on surfaces such as walls and ceilings after smoking happens. Owners of homes that have been previously smoked in are faced with unanswered questions about how to clean up the toxic substances left behind.

When tobacco is smoked, the particulates contained in secondhand smoke settle on surfaces; this contamination is absorbed deep into materials such as hair, clothes, carpeting, furniture, and wallboard [9,14]. After depositing onto surfaces, the chemicals undergo an aging process, which changes the chemical structure of the smoke pollutants. The nicotine in thirdhand smoke residue reacts with common indoor air pollutants, such as nitrous acid and ozone, to form hazardous substances. When the nicotine present in thirdhand smoke reacts with nitrous acid, it forms carcinogenic tobacco-specific nitrosamines such as NNK and NNN [15–17]. Nicotine also reacts with ozone to form additional harmful ultrafine particles that can embed deep within the lungs when inhaled [18]. As thirdhand smoke ages, it becomes more toxic [15]. The aged particles then undergo a process called "off-gassing," in which gas is continuously reemitted from these surfaces back into the air [19]. This process of off-gassing occurs long after cigarettes have been smoked indoors [19,20]. Thirdhand smoke particles can also be inhaled when they get resuspended into the air after contaminated surfaces are disturbed [21].

Common practices employed by smokers, like smoking in different rooms, using fans to diffuse the smoke, or opening windows, do not prevent the formation and inhalation of thirdhand smoke by people living or visiting these indoor spaces [22]. Environments with potential thirdhand smoke exposure include homes of smokers [23], apartments and homes previously occupied by smokers [24], multi-unit housing where smoking is permitted [25], automobiles that have been smoked in [26], hotel rooms where smoking is permitted [27], and other indoor places where smoking has occurred.

Research Supports Having Completely Smoke-Free Environments

Recent research has shown that exposure to thirdhand smoke is harmful. These findings, many of which are described below, offer strong support in favor of advocating for environments free of thirdhand smoke contamination for families and children.

Genetic Damage from Thirdhand Smoke Exposure

In 2013, researchers from the Lawrence Berkeley National Laboratory were the first to demonstrate that thirdhand smoke causes significant genetic damage to human cells [28]. Using in vitro assays, the researchers showed that thirdhand smoke is a cause of harm to

human DNA in the form of strand breaks and oxidative damage, which leads to mutations that can cause cancer. The researches also specifically tested the effect of NNA, a tobacco-specific nitrosamine that is commonly found in thirdhand smoke but not in secondhand smoke, on human cell cultures and found that it caused significant damage to DNA [28].

Children Show Elevated Biomarkers of Thirdhand Smoke Exposure in Their Urine and Hair Samples

In 2004, Matt and colleagues described how they collected household dust samples from living rooms and infants' bedrooms [23]. Their research demonstrated that nicotine accumulated on the living room and infants' bedroom surfaces of the homes belonging to smokers. Significantly higher amounts of urine cotinine, a biomarker for exposure to nicotine, were detected among infants who lived in homes where smoking happens inside compared to homes where smokers go outside to smoke [23]. As well, a study published in 2017 that measured the presence of hand nicotine on children of smokers who presented to the emergency room for an illness possibly related to tobacco smoke exposure detected hand nicotine on the hands of each child who participated in this pilot study. The researchers found a positive correlation between the amount of nicotine found on children's hands and the amount of cotinine, a biomarker for nicotine exposure, detected in the children's saliva [29].

Children Are Exposed to Higher Ratios of Thirdhand Smoke than Adults

In 2009, researchers discovered that the thirdhand smoke ratio of tobacco-specific nitrosamines to nicotine increases during the aging process [9]. Biomarkers measured in the urine can now be used to estimate the degree to which people have been exposed to secondhand or thirdhand smoke based on the ratio of the thirdhand smoke biomarker NNK and nicotine. Toddlers who live with adults who smoke have higher NNK/nicotine ratios, suggesting that they are exposed to a higher ratio of thirdhand smoke compared to secondhand smoke than adults [30]. Young children are likely exposed to higher ratios of thirdhand smoke as they spend more time on the floor, where thirdhand smoke accumulates. They frequently put their hands and other objects into their mouths. Young children breathe faster than adults, increasing their inhalation exposure and also have thinner skin, making dermal absorption more efficient [9].

Modeling Excess Cancer Risk

A 2014 United Kingdom study used official sources of toxicological data about chemicals detected in thirdhand smoke-contaminated homes to assess excess cancer risk posed from thirdhand smoke [17]. Using dust samples collected from homes where a smoker lived, they estimate that the median lifetime excess cancer risk from the exposure to all the nitrosamines present in thirdhand smoke is 9.6 additional cancer cases per 100,000 children exposed and could be as high as 1 excess cancer case per 1000 children exposed. The researchers concluded that young children aged 1 to 6 are at an especially increased risk for cancer because of their frequent contact with surfaces contaminated with thirdhand smoke and their ingestion of the particulate matter that settles on surfaces after smoking takes place [17].

Infants in Health Care Facilities Are Exposed to Thirdhand Smoke

Researchers have observed biomarkers confirming thirdhand smoke exposure in the urine of infants in the NICU. Found in incubators and cribs, particulates are likely being deposited in the NICU from visitors who have thirdhand smoke on their clothing, skin, and hair [31].

Animal Studies Link Thirdhand Smoke Exposure to Common Human Disease

Mice exposed to thirdhand smoke under conditions meant to simulate levels similar to human exposure are pre-diabetic, are at higher risk of developing metabolic syndrome, have inflammatory markers in the lungs that increase the risk for asthma, show slow wound healing, develop nonalcoholic fatty liver disease, and become behaviorally hyperactive [32]. Another recent study published in 2017 showed that mice exposed to thirdhand smoke after birth weighed less than mice not exposed to thirdhand smoke. Additionally, mice exposed to thirdhand smoke early in life showed changes in white blood cell counts that persisted into adulthood [9,33].

Summary

In summary, recent research makes a compelling case for invoking the precautionary principle to ensure that children avoid exposures to thirdhand smoke in their homes, cars, and health care settings. Studies reveal that:

- children live in homes where thirdhand smoke is present and this exposure is detectable in their bodies [23]
- concentrations of thirdhand smoke exposure observed in children are disproportionately higher than adults [30]
- chemicals present in thirdhand smoke cause damage to DNA [28]
- thirdhand smoke contains carcinogens that put exposed children at increased risk of cancer [17]
- thirdhand smoke is being detected within medical settings [34] and in the bodies of medically-vulnerable children [29], and
- animal studies have linked exposure to thirdhand smoke to a number of adverse health conditions commonly seen in today's pediatric population such as metabolic syndrome, prediabetes, asthma, hyperactivity [32] and low birth weight [33].

Using the Thirdhand Smoke Concept in Clinical Practice

The clinical setting is an ideal place to address thirdhand smoke with families as a component of a comprehensive tobacco control strategy.

The Cessation Imperative—A Novel Motivational Message Prompted by Thirdhand Smoke

While there are potentially many ways to address thirdhand smoke exposure with families, the CEASE (Clinical Effort Against Secondhand Smoke Exposure) program has been used in the primary care setting to train child health care clinicians and office staff to address

second- and thirdhand smoke. The training also educates clinicians on providing cessation counseling and resources to families with the goal of helping all family members become tobacco free, as well as to helping families keep completely smoke-free homes and cars [35,36]. The concept of thirdhand smoke creates what we have coined the *Cessation Imperative* [36]. The Cessation Imperative is based on the notion that the only way to protect non-smoking family and household members from thirdhand smoke is for all household smokers to quit smoking completely. Smoking, even when not in the presence of children, can expose others to toxic contaminates that settle on the surfaces of the home, the car as well as to the skin, hair, and clothing of family members who smoke. A discussion with parents about eliminating only secondhand smoke exposure for children does not adequately address how continued smoking, even when children are not present, can be harmful. The thirdhand smoke concept can be presented early, making it an efficient way to advocate for completely smoke-free families.

Thirdhand Smoke Counseling Helps Clinicians Achieve Key Tobacco Control Goals

The American Academy of Pediatrics (AAP) and the American Academy of Family Physicians (AAFP) recommend that health care providers deliver advice to parents regarding establishing smoke-free homes and cars and provide information about how their smoking adversely affects their children's health [37,38]. It is AAP and AAFP policy that health care providers provide tobacco dependence treatment and referral to cessation services to help adult family members quit smoking [38,39]. Successfully integrating counseling around the topic of thirdhand smoke into existing smoking cessation service delivery is possible. The CEASE research and implementation team developed and disseminated educational content to clinicians about thirdhand smoke through AAP courses delivered online [40] as well as made presentations to clinicians at AAP-sponsored training sessions. Thirdhand smoke messaging has been included in the CEASE practice trainings so that participating clinicians in pediatric offices are equipped to engage parents on this topic. Further information about these educational resources and opportunities can be obtained from the AAP Julius B. Richmond Center of Excellence website [41] and from the Massachusetts General Hospital CEASE program's website [42].

Counseling parents about thirdhand smoke can help assist parents with their smoking in the critical context of their child's care. Most parents see their child's health care clinician more often than their own [43]. Increasing the number of pediatric clinical encounters where parental smoking is addressed while also increasing the effectiveness of these clinical encounters by increasing parents' motivation to protect their children from tobacco smoke exposure are important goals. The topic of thirdhand smoke is a novel concept that clinicians can use to engage with parents around their smoking in a new way. Recent research conducted by the CEASE team suggests that counseling parents in the pediatric setting about thirdhand smoke can be useful in helping achieve tobacco control goals with families. Parent's belief about thirdhand smoke is associated with the likelihood the parent will take concrete steps to protect their child. Parents who believe thirdhand smoke is harmful are more likely to protect their children from exposure by adopting strictly enforced smoke-free home and car rules [44]. Parents who changed their thirdhand smoke beliefs over the course

of a year to later believe that thirdhand smoke is harmful were more likely to try to quit smoking [44].

Child health care clinicians are effective at influencing parents' beliefs about the potential harm thirdhand smoke poses to their children. Parents who received advice from pediatricians to quit smoking or to adopt smoke-free home or car policies were more likely to believe that thirdhand smoke was harmful to the health of children [45]. Fathers (as compared with mothers) and parents who smoked more cigarettes each day were less likely to accept that thirdhand smoke is harmful to children [45]. Conversely, delivering effective educational messages and counseling around the topic of thirdhand smoke to parents may help promote smoke-free rules and acceptance of cessation assistance.

Protect Patients from Thirdhand Smoke Risks

All health care settings should be completely smoke-free. Smoking bans help protect all families and children from second and thirdhand smoke exposure. It is especially important for medically vulnerable children to visit facilities free from all forms of tobacco smoke contamination. CEASE trainings encourage practices to implement a zone of wellness on the grounds of the health care facility by completely banning smoking. The CEASE implementation team also trains practice leaders to reach out to all staff that use tobacco and offer resources and support for quitting. Having a non-smoking staff sets a great example for families who visit the health care facility, and reduces the likelihood of bringing thirdhand smoke contaminates into the facility. Creating a policy that addresses thirdhand smoke exposure is a concrete step that health care organizations can take to protect patients.

Thirdhand Smoke Resources Developed and/or Used by the CEASE Program

The CEASE program has developed and/or identified a number of clinical resources to educate parents and clinicians about thirdhand smoke. These free resources can enhance awareness of thirdhand smoke and help promote the use of the thirdhand smoke concept in clinical practice.

- Posters with messages designed to educate parents about thirdhand smoke to encourage receipt of cessation resources were created for use in waiting areas and exam rooms of child health care practices. A poster for clinical practice (Figure 1) can be downloaded and printed from the CEASE program website [42].
- Health education handouts that directly address thirdhand smoke exposure are available. The handouts can be taken home to family members who are not present at the visit and contain the telephone number for the tobacco quitline service, which connects smokers in the United States with free telephone support for smoking cessation. Handouts for clinical practice can be downloaded and printed from the CEASE program website. Figure 2 shows a handout that encourages parents to keep a smoke-free car by pointing out that tobacco smoke stays in the car long after the cigarette is out.
- Videos about thirdhand smoke can be viewed by parents while in child health care offices or shared on practice websites or social media platforms. The

CEASE program encourages practices to distribute videos about thirdhand smoke to introduce parents to the concept of thirdhand smoke and to encourage parents to engage in a discussion with their child's clinicians about ways to limit thirdhand smoke exposure. Suitable videos for parental viewing include the 2 listed below, which highlight information from the Thirdhand Smoke Research Consortium.

- University of California Riverside https://youtu.be/i1rhqRy-2e8
- University of California San Diego https://youtu.be/rqzi-9sXLdU

- Letters for landlords and management companies were created to stress the importance of providing a smoke-free living environment for children. The letters are meant to be signed by the child's health care provider. The letters state that eliminating smoking in their buildings would result in landlords that "Pay less for cleaning and turnover fees." Landlord letter templates can be downloaded and printed from the CEASE program website [42].
- Educational content for child health care clinicians about thirdhand smoke and how to counsel parents is included in the American Academy of Pediatrics Education in Quality Improvement for Pediatric Practice (EQIPP) online course entitled *Eliminating Tobacco Use and Exposure to Secondhand Smoke*. A section devoted to educating clinicians on the topic of thirdhand smoke is presented in this course. The course can be accessed through the AAP website and it qualifies for American Board of Pediatrics maintenance of certification part IV credit [40].

The CEASE team has worked with mass media outlets to communicate the messages about thirdhand smoke to build public awareness. The Today Show helped to popularize the concept of thirdhand smoke in 2009 after a paper published in the journal *Pediatrics* linked thirdhand smoke beliefs to home smoking bans [2].

Systems Approaches to Reduce Thirdhand Smoke Exposure

Public Policy Approaches

A clear policy agenda can help people protect their families from exposure to thirdhand smoke [46]. Policy approaches that have worked for lead, asbestos, and radon are examples of common household contaminants that are regulated using different mechanisms in an effort to protect the public health [46]. Strengths and weaknesses in each of these different approaches should be carefully considered when developing a comprehensive policy agenda to address thirdhand smoke. Recently, research on the health effects of thirdhand smoke spurred the passage of California legislative bill AB 1819 that "prohibits smoking tobacco at all times in the homes of licensed family child care homes and in areas where children are present [47]." As well, a recent US Department of Housing and Urban Development rule was finalized that requires all public housing agencies to implement a smoke-free policy by July 30, 2018 [48]. Smoke-free housing protects occupants from both secondhand and thirdhand smoke exposure. Pediatricians and other child health care professionals are well

positioned to advocate for legislative actions that protect children from harmful exposures to thirdhand smoke.

Practice Change in Child Health Care Settings

Designing health care systems to screen for tobacco smoke exposure and to provide evidence-based cessation resources for all smokers is one of the best ways to reduce exposures to thirdhand smoke. Preventing thirdhand smoke exposure can work as novel messaging to promote tobacco cessation programs. Developing electronic medical record systems that allow for documentation of the smoking status of household members and whether or not homes and cars are completely smokefree can be particularly helpful tools for child health care providers when addressing thirdhand smoke with families. Good documentation about smoke-free homes and cars can enhance follow-up discussions with families as they work towards reducing thirdhand smoke exposures.

Summary

The thirdhand smoke concept has been used to improve delivery of tobacco control counseling and services for parents in the child health care context. Free materials are available that utilize thirdhand smoke messaging. As the science of thirdhand smoke matures, it will increasingly be used to help promote completely smoke-free places. The existing research on thirdhand smoke establishes the need for clinicians to communicate the cessation imperative. By using it, clinicians can help all smokers and non-smokers understand that there is no way to smoke tobacco without exposing friends and family.

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Figure 1.
Poster for use in waiting area or exam room to educate parents about thirdhand smoke and to encourage receipt of cessation resources.

Figure 2.
Handout that encourages parents to keep a smoke-free car by pointing out that tobacco smoke stays in the car long after the cigarette is out.