Introduction

It took decades to prove that cigarette smoking causes cancer, heart disease and early death.\(^1\) The smoke inhaled by the smoker by burning of tobacco encased in cigarette, pipes and cigar is called ‘Firsthand Smoke’ (FHS). ‘Secondhand Smoke’ (SHS) is the smoke we inhale when others smoke. It is also called ‘environmental tobacco smoke’. It is of two kinds. One is the smoke given off by the burning end of a cigarette, pipe or cigar which is called ‘the side-stream smoke’. The other is the smoke exhaled by the smoker, called the ‘mainstream smoke’.\(^2\) It took additional years to establish that secondhand smoke also kills. Now scientists are worried about another cigarette-related phenomenon: ‘Third hand Smoke’ (THS). It's real, and it's ubiquitous. Without knowing it, indoor smokers have left a toxic legacy that continues years after their last butt was stubbed out.\(^1\) It is also known as ‘residual’ or ‘aged tobacco smoke’. THS is, in the words of The New York Times, “the invisible yet toxic brew of gases and particles clinging to smokers’ hair and clothing, not to mention cushions and carpeting that lingers long after secondhand smoke [SHS] has cleared from a room.”

How does SHS differ from THS

SHS is a mixture of the side stream smoke (i.e., smoke emitted from the burning cigarette, pipe, or cigar) and the mainstream smoke exhaled from the lungs of smokers. SHS contains more than 4,000 chemicals, many of which are known or suspected contributors to adverse health effects. These chemicals include ammonia, acrolein, carbon monoxide, formaldehyde, hydrogen cyanide, nicotine, nitrogen oxides, polycyclic aromatic hydrocarbons (PAHs), and sulfur dioxide, as well as other chemicals that are eye and respiratory irritants, mutagens, carcinogens, and cardiovascular and...
reproductive toxicants (U.S. Department of Health and Human Services 2006).3,9

THS consists of residual tobacco smoke pollutants that remain on surfaces and in dust after tobacco has been smoked, are re-emitted into the gas phase, or react with oxidants and other compounds in the environment to yield secondary pollutants. The constituents of THS identified to date include nicotine, 3-ethenylpyridine (3-EP), phenol, cresols, naphthalene, formaldehyde, and tobacco-specific nitrosamines (including some not found in freshly emitted tobacco smoke) 4-9

Historical perspective of THS

THS was a topic of interest long before it received its present name. The seed of the idea that cigarette smoke toxicants might linger on room and car surfaces long after the smoke itself was gone was planted in 1953, when it was reported that smoke condensate painted onto mice caused cancer.11

In 1991 the house dust of smokers’ homes was first found to be contaminated with nicotine.12 Later, in 2004, nicotine was quantified in the dust of nonsmokers’ homes and homes in which mothers smoked in the house over the preceding 3 months. In homes with the highest SHS exposure, in which the mothers smoked in areas where their children were present, nicotine in dust averaged 64.0 µg/m² in living rooms and 15.8 µg/m² in infants’ bedrooms. Surfaces in living rooms and infants’ bedrooms averaged nicotine coatings of 73.05 µg/m² and 56.26 µg/m², respectively. The same study showed the dust and surfaces of homes in which smokers had tried to limit their children’s exposure (for instance, by sometimes smoking outdoors) were also contaminated, although to a lesser degree. However, no nicotine was found in the dust or on the surfaces of homes never exposed to tobacco smoke.13

In 2008 similar findings were reported for cars.14 Nicotine was detected in significantly greater quantities in the dust (mean 19.51 µg/g) and on the dashboards (mean 8.61 µg/m²) of 78 vehicles belonging to people who smoked in their vehicles than in the dust (mean 3.37 µg/g) and on the dashboards (mean 0.06 µg/m²) of 20 vehicles of nonsmokers. Eight smokers had imposed a smoking ban in their vehicles for at least 12 months. Their vehicles nevertheless were contaminated with nicotine (mean 11.61 µg/g in dust and 5.09 µg/m² on the dashboard). The authors point out, however, that the cars may have been contaminated by smoke that entered the car from outside and that smoking bans may not have been complied with 100% of the time.

A 2010 study showed THS also remains after smokers move out of their homes, even after being vacant for two months and being prepared for new residents, sometimes with new carpeting and paint.15 Meanwhile, other lines of research have confirmed some smoke compounds adsorb onto surfaces and then desorbs back into the air over time, providing a source of tobacco toxicants that lingers long after people finish smoking.5,6

The term thirdhand smoke may have first appeared in print in 2006,16 but it became more widely known in 2009 when it was used by Jonathan Winickoff, an associate professor of pediatrics at Harvard Medical School, and colleagues in a paper published in Pediatrics.17

In that work, the researchers reported that 65.2% of nonsmokers and 43.3% of smokers believed THS could harm children and that such beliefs were independently associated with the imposition of home smoking bans. The authors also wrote that emphasizing the potential dangers of THS to children’s health might be important in encouraging parents not to smoke around their children.

A new development emerged when Mohamad Sleiman, a chemist with the Indoor
Environment Department of the Lawrence Berkeley National Laboratory (LBNL) Environmental Energy Technologies Division, and colleagues reported that nicotine adsorbed onto surfaces reacted with nitrous acid—an air pollutant found in vehicle exhaust and produced by improperly vented gas stoves and burning tobacco—to form tobacco-specific nitrosamines (TSNAs) including 1-(N-methyl-N-nitrosamino)-1-(3-pyridinyl)-4-butanal (NNA), 4-(N-nitrosomethylamino)-1-(3-pyridinyl)-1-butanone (NNK), and N-nitrosonornicotine (NNN). There is some evidence NNA is mutagenic. NNK and NNN are classified by the International Agency for Research on Cancer as human carcinogens and by the National Toxicology Program as reasonably anticipated to be human carcinogens.

Later in 2010 Sleiman et al. reported that ozone, another indoor air pollutant, reacted with some 50 compounds in SHS to produce ultrafine particles smaller than 100 nm, the compositions of which are yet to be determined. The effects of ultrafine particles are thought to vary depending on their composition and characteristics, but their tiny size likely facilitates their uptake and distribution throughout the body to potentially sensitive target sites including the bone marrow, lymph nodes, spleen, heart, and central nervous system.

Sleiman et al. also speculated these ultrafine particles may be capable of depositing on surfaces and later resuspending into the air. In the same year, another research team provided the first preliminary quantitative data showing these particles did just that, although reaching airborne concentrations 100 times lower than levels in SHS.

By the latter part of 2010, with thirdhand smoke an established moniker, researchers began to define the phenomenon with a “three Rs” description: “Thirdhand smoke consists of residual tobacco smoke pollutants that remain on surfaces and in dust after tobacco has been smoked, are re-emitted back into the gas phase, or react with oxidants and other compounds in the environment to yield secondary pollutants,” Sleiman says. SHS exposure results from the involuntary inhalation of sidestream and exhaled mainstream smoke. In contrast, THS exposure results from the involuntary inhalation, ingestion, or dermal uptake of THS pollutants in the air, in dust, and on surfaces. Such exposure includes inhalation exposure to compounds re-emitted into the air from indoor surfaces and particles resuspended from deposits and dermal and ingestion exposure to compounds partially derived from cigarette smoke and resulting particles that have settled, deposited, and accumulated on surfaces.

Although the term THS is relatively new, the chemical aging of tobacco smoke, the evidence THS leaves behind in indoor environments (e.g., cigarette butts, unpleasant odor, smelly clothes), and its aversive impact on nonsmokers have long been recognized. We favor the term “thirdhand smoke,” rather than alternative terms such as aged tobacco smoke or residual SHS, to stress that THS is the legacy of tobacco smoke, it evolves from SHS and, similar to SHS, it leads to involuntary exposure to tobacco smoke pollutants. Although it is important to distinguish SHS from THS because of significant chemical, toxicological, and behavioral differences, SHS and THS are closely related and coexist during the early period of THS formation and in contaminated environments in which smoking takes place episodically.

Based on our definitions of SHS and THS, total tobacco smoke exposure is the cumulative involuntary exposure to tobacco smoke pollutants during and after the time in which cigarettes are smoked. The exposure risk does not end when a cigarette has been extinguished and may persist in the absence of further
smoking, because THS pollutants trapped and deposited on surfaces and in dust, persist in environments in which smoking took place at some earlier points in time.9

**Those affected by THS**

No one knows, in this relatively new field of research, how long the compounds created by smoke and environmental pollutants last. "In homes where we know no smoker has lived for 20 years, we've still found evidence of these compounds in dust, in wallboard," says Neal Benowitz, chief of the Division of Clinical Pharmacology at the University of California, San Francisco. Benowitz leads the California Consortium on Thirdhand Smoke, started in 2010. Scientists do know that babies, toddlers, and children are most vulnerable to the toxic effects of tobacco smoke residue. They crawl on rugs, fall asleep on carpets, and teethe on furniture, all of which could be saturated with thirdhand smoke. Researchers aren't just worried about the risk of cancer. Thirdhand smoke could be responsible for other health problems, including asthma attacks and allergic reactions. Hotel workers who sweep, vacuum, change linens, and dust the rooms of smokers are exposed to higher doses of thirdhand smoke than are the guests who stay a few nights in smoking rooms. Science hasn't yet quantified the amount of exposure that poses a health risk, and hasn't determined with certainty what those health risks might be. But any bar, casino, rental car, or indoor space that welcomed smokers in the past could still have ample amounts of thirdhand smoke. Those who move into houses or apartments formerly owned by smokers might be exposed as well. And thirdhand smoke is difficult to eliminate. "So far, we have not found an exposed environment where you cannot measure it anymore," says Georg Matt, chair of the Department of Psychology at San Diego State University in California. "It's virtually impossible to remove this stuff unless you remove the flooring and drywall." 1

**Clinical significance of THS**

Human exposure to constituents of THS has not been well characterized, and it is therefore premature to assess the health risk of THS. Given this caveat, one can consider how some of the known THS components could affect human health. The chemicals that mediate adverse health consequences can be considered in categories such as irritants, carcinogens, and mutagens (e.g., TSNAs, PAHs, heavy metals, nicotine). Nicotine plays multiple roles in carcinogenesis through inhibition of apoptosis and cell proliferation.26-28 It is known to affect oxidative stress and to have adverse effects on brain and lung development in children.28 Nicotine may have adverse effects on vascular function and might promote inflammation.29 Because nicotine and other THS constituents may be transformed into new toxicants18,22, concerns about potential health risks of THS must include compounds created through secondary reactions.

An important question is how many of the known carcinogens identified by the International Agency for Research on Cancer (IARC) that are found in mainstream and sidestream smoke are continuously or intermittently present in THS.30 TSNAs, such as NNK, are potent lung carcinogens, and some TSNAs form from nicotine on indoor surfaces through chemical reactions with ambient nitrous acid.31 See for an initial effort to quantify the potential exposure to NNA and NNK via dermal transfer.32 PAHs in tobacco smoke, particularly benzo[a]pyrene, are also carcinogenic30. Particles and oxidant gases produce free radical species and oxidant injury that can promote inflammation, affect immune function, and activate thrombotic mechanisms.33,34 Oxidant and irritant gases can trigger allergic symptoms and asthma.35
Public Health Implications

Risk assessment will require the development of biomarkers of THS exposure. A logical initial focus for a selective biomarker might be metabolites of NNA, because NNA is the major TSNA formed from the reaction of nicotine and nitrous acid and has not been found in tobacco smoke. Likely metabolites are iso-NNAL [1-(N-methyl-N-nitrosamino)-1-(3-pyridinyl)-4-butanol] and iso-NNAC (4-(N-methyl-N-nitrosamino)-4-(3-pyridinyl)-butanoic acid), which might be measurable in urine. NNA or other substances derived from it might be suitable as markers of THS in dust or surfaces.9

Risk assessments will benefit from careful consideration of sensitive populations (e.g., young children, medically compromised persons) and at-risk environments (e.g., low-income housing). Because of the immature stage of their biological and behavioral development, the level of exposure and health risks are likely to be greatest for young children who are in direct contact with polluted surfaces and house dust.9

Prevention and Control of THS

Even though THS is a dynamic mixture of chemical compounds, it is important to remember that it is a consequence of smoking behavior, which is a modifiable human activity with well-understood harmful health outcomes.9

Experts have precious few suggestions for ridding an indoor environment of thirdhand smoke. A pretty thorough cleaning up with detergent is important. Sealing and repainting the room where smoking was done. The best approach is to replace the sofa and carpets, replacing sometimes the contaminated wall board and clean up the ventilation system. All this could help. Much more work needs to be done on the extent of the problem, the health risks, and effective ways to clean up the compounds. Parents are advised not to expose their children to thirdhand smoke, not to rent hotel rooms or cars used by smokers. It is better to avoid if one can avoid it.1

Knowledge about THS could be used clinically to encourage home and car smoking bans among individuals and to promote cessation.9

Policy Implications of THS for Overall Tobacco Control

Although it is premature to formulate public policies in response to potential THS health risks, it is important noting that numerous voluntary private policies have emerged over the past 10 years targeting THS. Major international, national, and local hotels (e.g., Marriot, Westin) and car rental companies (e.g., Avis, Enterprise, Hertz) have adopted complete or partial smoking bans to protect nonsmokers from the effects of lingering tobacco smoke. These policies grew out of complaints and concerns about unpleasant odor, respiratory symptoms, and eye irritation among hotel guests and customers of rental cars. Similar consumer preferences for smoke-free environments are also noticeable in the used car and real estate markets. Research conducted in southern California has shown that used cars of smokers were valued 8–9% lower than were the equivalent priced cars owned by nonsmokers36, and rental apartments remained vacant longer and required higher maintenance costs37 when they were occupied by smokers rather than nonsmokers.

Public Health Concerns of THS in India

Though the Government of India has in place warnings, regulations and legislations for the control of smoking and other forms of tobacco use, very little has translated into action. Smoking among the people both young and old alike continues unabatedly in public places with sheer lack of concern for others. Government of India and other Non-Governmental Agencies have created enough awareness on effects of
smoking (FHS) and passive smoking (SHS) on health. Even the World Health Organization on World No Tobacco Day on 31st May exhorts governments to raise taxes on tobacco products to such an extent so as to discourage people of low income groups and young people from using tobacco. Now that the threat of THS looms large it is high time one should think and reflect before smoking the damage he or she does to the people especially young generation and the environment alike. Awareness on THS should be brought into the public domain and mass media communications, school children, college students and professionals should be actively involved for this.

Conclusion

The various studies on THS provide new insights about understanding the long term effects of tobacco use and also on the modus operandi of prevention and retrenchment of tobacco use. The existing evidence on THS provides a formidable support to pursue a programmatic research agenda to plug important lacunae in our current understanding of the chemistry, toxicology, pollution, exposure, clinical significance, and policy implications of THS. A research program on these lines is therefore mandatory to highlight the role of THS in the present and future tobacco control efforts to decrease smoking initiation and smoking levels, to increase cessation attempts and sustained cessation, and to reduce the cumulative effects of tobacco use on morbidity and mortality.

References


2. Tobacco Smoke. Available at : www.arhp.org / files / Smoke _Secondhand_Smoke.pdf[/ accessed Apr 18th 2014]


