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Swiss association for tobacco control

The Hidden Residue of Tobacco: Composition, Persistence, and Impact of Passive Smoke

Passive smoke refers to the unintended exposure of nonsmokers to the harmful byproducts of tobacco smoke. It encompasses two distinct forms: Secondhand smoke (SHS), made up of mainstream and side stream smoke, and thirdhand smoke (THS), which refers to the residual chemicals from tobacco smoke that remain on surfaces, in dust, and in the environment long after smoking has stopped. While traditionally "passive smoke" was used interchangeably with SHS, modern research broadens the term to include both SHS and THS (Protano & Vitali, 2011).

The following sections will review the composition, persistence, and exposure pathways of secondhand and thirdhand smoke, highlighting their distinct characteristics and cumulative impact in indoor environments.

Secondhand Smoke (SHS): Composition and Toxicity

SHS consists of two main components: Sidestream smoke, which is emitted directly from the burning end of a cigarette, and mainstream smoke, which is exhaled by the smoker after inhalation (Sikorska-Jaroszyńska et al., 2012). Sidestream smoke is significantly more toxic than mainstream smoke and can be up to four times more carcinogenic, posing serious health risks even at typical indoor exposure levels. This heightened toxicity is partly because sidestream smoke does not pass through the smoker's lungs, meaning it is not filtered or chemically altered before entering the environment. Additionally, it is produced at a lower combustion temperature (400–600 °C compared to 900 °C during inhalation), which leads to incomplete burning and the formation of higher concentrations of harmful substances such as polycyclic aromatic hydrocarbons (PAHs) and tobacco-specific nitrosamines (TSNAs)—both known carcinogens (Schick & Glantz, 2005; U.S. Department of Health and Human Services [USDHHS], 2006). SHS contains thousands of harmful chemicals, including fine particulate matter and heavy metals such as chromium, nickel, arsenic, cadmium, and lead—many of which are concentrated in small particles that penetrate deep into the lungs (Slezakova et al., 2009). As tobacco smoke diffuses into indoor air, it undergoes chemical transformations. For example, nicotine transitions into vapor quickly, but other toxic elements persist on indoor surfaces and in household dust (Baker & Proctor, 1990). These deposited substances contribute to the formation of THS.

Thirdhand Smoke (THS): A Persistent and Overlooked Hazard

Unlike SHS, which is inhaled during or shortly after smoking, THS is the toxic residue left behind after smoke has cleared. It is made up of several hazardous substances such as tobacco-specific nitrosamines (TSNAs), which are potent carcinogens, polycyclic aromatic hydrocarbons (PAHs), which settle on surfaces, nicotine, which reacts with indoor pollutants such as nitrous acid to form additional TSNAs, volatile organic compounds (VOCs) like acrolein and formaldehyde, heavy metals such as lead and arsenic as well as radioactive elements (James et al., 2022).
These residues settle on surfaces such as furniture, walls, and carpets or embed themselves in dust. Over time, they can re-enter the air, be resuspended, or react with indoor chemicals to form new toxic compounds (Ferrante et al., 2013).

Persistence

Numerous studies confirm THS contamination is extremely persistent, resisting standard cleaning and ventilation: In homes previously occupied by smokers, even after two months of vacancy and cleaning, nicotine in dust, air, and surfaces remain elevated. New nonsmoking residents exhibit increased levels of nicotine on their fingers and cotinine in urine, indicating ongoing exposure (Matt et al., 2011). In other cases, even when cleaning reduced contamination initially, surface and dust nicotine levels rebounded to pre-cleaning levels within three months (Matt et al., 2021). In used vehicles, cleaning, ventilation, or smoking with windows down did not significantly reduce THS levels (Fortmann et al., 2010).

Cumulative Exposure

Cumulative exposure to tobacco smoke indoors results from the combined presence of both SHS and THS. SHS exposure typically involves short-term, high-level contact with airborne pollutants during or shortly after smoking. In contrast, THS exposure is more chronic and occurs at lower levels over extended periods. It takes place through various pathways, including inhalation of re-emitted gases or resuspended particles, dermal absorption from contaminated surfaces, and ingestion of tobacco-laden dust. As a result, an individual's total tobacco smoke exposure in indoor environments reflects the cumulative impact of both SHS and THS (James et al., 2022).

Exposure Measures

To assess exposure to passive smoke, researchers use both environmental and biological monitoring methods. Environmental monitoring involves measuring airborne

nicotine and particulate matter (PM), which provide insight into the presence and concentration of tobacco smoke in indoor spaces (Apelberg et al., 2013).

Biological monitoring relies on biomarkers such as cotinine (a nicotine metabolite) and NNAL (a metabolite of the carcinogen NNK), which can be detected in blood, urine, saliva, hair, and toenails (Avila-Tang et al., 2013). However, studies show that nicotine retention differs between individuals, which makes it difficult to rely on nicotine alone as an indicator for exposure (McAughey et al., 1994).

Conclusion

Both SHS and THS represent serious and ongoing health threats, particularly in indoor environments where contamination can linger for a long time. While SHS is more widely recognized, emerging research underscores the long-term danger of THS, especially its ability to persist, react, and expose nonsmokers over time. Effective public health responses must therefore address not only direct smoking and SHS exposure, but also residual contamination from THS through prevention, regulation, and improved public awareness.

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