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Waterpipes and e-cigarettes: Impact of alternative smoking techniques on indoor air quality and health

Hermann Fromme*, Wolfgang Schober

Bavarian Health and Food Safety Authority, Department of Chemical Safety and Toxicology, Pfarrstrasse 3, D-80538 Munich, Germany

HIGHLIGHTS

- Waterpipe (WP) smoking and E-cigarette has increased in the last years.
- WP smoke is responsible for various adverse effects in humans.
- E-cigarettes vapers can be exposed to substantial amounts of harmful substances.
- More research on the safety of e-cigarettes is needed.

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ABSTRACT

Waterpipe (WP) smoking is growing as an alternative to cigarette smoking, especially in younger age groups. E-cigarette use has also increased in recent years. A majority of smokers mistakenly believe that WP smoking is a social entertainment practice that leads to more social behavior and relaxation and that this type of smoking is safe or less harmful and less addictive than cigarette smoking. In reality, WP smokers are exposed to hundreds of toxic substances that include known carcinogens. High exposures to carbon monoxide and nicotine are major health threats. Persons exposed to secondhand WP smoke are also at risk. There is growing evidence that WP smoke causes adverse effects on the pulmonary and cardiovascular systems and is responsible for cancer.

E-cigarettes are marketed as a smokeless and safe way to inhale nicotine without being exposed to the many toxic components of tobacco cigarettes, and as an aid to smoking cessation. In fact, consumers (vapers) and secondhand vapers can be exposed to substantial amounts of VOC, PAH or other potentially harmful substances. Of major health concern is the inhalation of fine and ultrafine particles formed from supersaturated 1,2-propanediol vapor. Such particles can be deposited in the deeper parts of the lung and may harm the respiratory system or increase the risk of acquiring asthma. More research on the safety of e-cigarettes needs to be conducted to ensure a high level of public health protection in the long-term.

1. Introduction

It has been well documented in the last few decades that tobacco smoking is related to diverse major health threats that result in approximately 440,000 deaths each year in the US alone. The cost is approximately $157 billion in annual health-related economic losses as well as more than 5.6 million years of potential life lost each year (e.g., US-DHHS, 2006). There is convincing evidence from numerous experimental and epidemiological studies that environmental tobacco smoke (ETS), often referred to as “secondhand smoke”, causes an increase in lung cancer and cardiovascular diseases and is responsible for other severe health effects, such as bronchial asthma, middle ear infections, sudden infant death syndrome (SIDS), pre-term delivery, and low birth weight. Consequently, ETS has been classified as a human carcinogen by diverse scientific organizations (IARC, 2004; US-DHHS, 2006; US-DHHS, 2010). ETS is a complex mixture of thousands of gaseous substances and particles that comprise the combustion products of tobacco and of charcoal as well as the smoke exhaled by the smoker (NRC, 1986). The ETS composition varies depending on the heat of combustion, the tobacco content, the additives that are present, and the type of filter material. Reducing the health effects attributed to smoking is an important public health initiative. Despite general efforts, we have observed few changes in the use of tobacco-related products as well as the development of new smoking techniques in western countries. Waterpipe smoking has

* Corresponding author.
E-mail address: hermann.fromme@lgl.bayern.de (H. Fromme).

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increased as an alternative to cigarette smoking, especially in younger age groups (WHO, 2005). E-cigarettes use has also increased in recent years. This increased usage necessitates an investigation of whether these techniques cause harmful exposure situations or adverse health effects. It is important to ensure that these techniques are not harmful and that they do not undermine the smoking prevention and cessation efforts of the last few decades.

Apart from possible health risks to users, our paper focuses on the concentrations of combustion and vapor products that are emitted or formed during the smoking of waterpipes or vaping e-cigarettes indoors and on the exposures of users and of persons unintentionally exposed to secondhand smoke. In addition to the characterization of external exposure, the determination of the body burden of the target substances or their urinary metabolites is an accurate method of obtaining important information to use in a risk assessment (Angerer et al., 2011). We focused predominantly on nicotine and its transformation products, cotinine and trans-3-hydroxycotinine, as well as on tobacco-related nitrosamines, all of which are specific biomarkers of tobacco smoke exposure in humans (Benowitz et al., 2009). The determination of the content of mercapturic acids in urine is also a good indication of the absorbed internal dose of a carcinogen, because mercapturic acids are metabolites of the highly reactive components of tobacco smoke (Schettgen et al., 2008). Moreover, carboxyhemoglobin (COHb) in blood and exhaled carbon monoxide (eCO) are easy, reliable and immediately available biomarkers that are related to exposure to carbon monoxide (CO) and that have been consistently used in numerous studies (e.g., Prockop and Chichkova, 2007; Jarvis et al., 1986). Additionally, some studies have shown that exhaled nitrogen oxide (eNO) is a reliable effect marker of eosinophilic inflammation in the lung (Smith et al., 2005; Turner, 2008; Dressel et al., 2008).

The aim of the present paper was to summarize in detail the recent data on exposure to WP smoking and e-cigarette vapor, especially in indoor environments. Moreover, the known health effects based on currently available toxicological or epidemiological data are discussed. We used the results of various Medline and Web of Science inquiries to obtain an overview of the current scientific literature. We also included papers presented at conferences; reports from governmental, scientific and other institutions; and where possible, unpublished reports and other gray literature.

2. Waterpipe smoking

Waterpipe (WP) smoking is a traditional practice with roots in ancient India that is most popular in Middle Eastern and South Asian countries. The WP is known by many names, such as the oriental pipe, arghileh, narghileh, narguila, hookah, shisha, chicha, gozah, and ghalyan. Traditionally, unsweetened and unflavored nicotine-rich tobaccos named jurak, ajami, and tumbak were smoked (Knishkowky et al., 2005). Today, 5–20 g of maassel (or muassel) is used, which consists of ~30% tobacco and ~70% honey or molasses. Maassel is flavored with additives such as apple, mango, mint, cappuccino, etc. The nicotine concentrations in the tobacco (maassel) vary between 1.8 and 6.3 mg/g (Hadidi and Mohammed, 2004). In a typical WP, charcoal heats the tobacco; the charcoal is separated from the tobacco by aluminum foil. When the smoker draws air through the mouthpiece of the hose, charcoal-heated air becomes smoke and passes through a bowl filled with water before being inhaled by the user (Maziak et al., 2011). A scheme of a typical WP is shown in Fig. 1. During a WP smoking session, smokers are exposed to more smoke over a longer period of time than in cigarette smoking because of the longer duration of such a session and because of the higher respiratory volume inhaled.

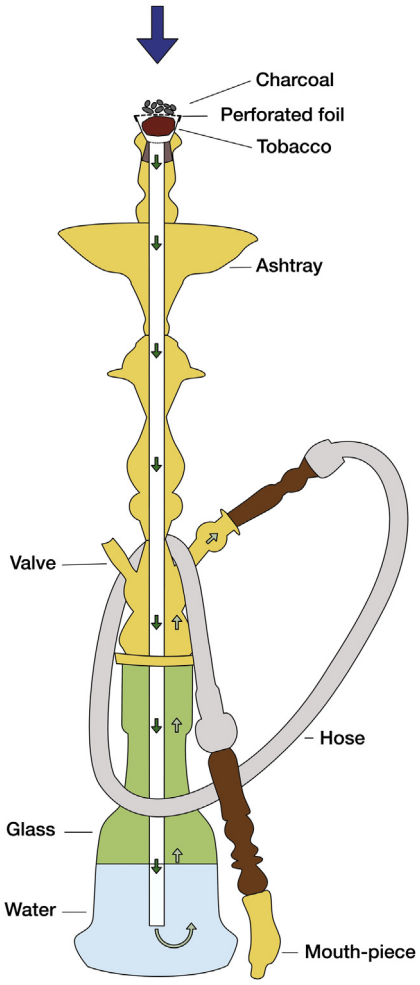

Fig. 1. Schematic of a waterpipe.

2.1. Occurrence

Traditionally, WP smoking is common in Mediterranean and Arabian countries. A recent review stated that in the Eastern Mediterranean region, 5–15% of adults are currently WP smokers and 63% have smoked a WP (Akl et al., 2011). The BREATHE study performed by interviewing 65,154 persons over 40 years old by telephone about their smoking habits found an average prevalence of WP smoking of 2% (maximum: 5.7%) in 10 countries in the Middle East and North Africa (Khattap et al., 2012). A survey of 13 middle-income countries around the world that enrolled adults who were >15 years old from a total of 288,800 households found a daily prevalence between 0.3% and 11% among men and from 0 to 0.3% among women (Morton et al., 2013). Higher prevalences of WP smoking of 9–15% and 6–28% were observed with pupils and university students, respectively (Akl et al., 2011). Up to 66% and 46% of these persons had smoked a WP.

Current WP smoking has been observed in 16.7% of Arab Americans and in 11.3% of non-Arab youth 14–18 years of age (*n*: 2782) in the Midwest USA (Weglicki et al., 2007, 2008). A logistic regression showed that students were 11 times more likely to be current WP smokers if they currently smoked cigarettes; if one or more family members smoked WPs in the home, the youth were 6.3 times more likely to be current WP smokers. In Michigan, in a total of 1455 high school students, 8% of the Arab Americans regularly used a WP, as did 3% of the non-Arab subjects (Rice et al.,