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Invited Review

Acute and Long-term Effects of Water Pipe Smoking on the Respiratory System: A Narrative Review

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Abstract

Tobacco use has become a global major health problem and a leading global cause of preventable death. Water pipe smoking epidemic is on the rise and is replacing cigarettes as the most popular method of tobacco use in many countries. In this narrative review, we aimed to summarize the acute and long-term effects of water pipe smoking on the respiratory system. A comprehensive literature search addressing these effects was conducted without date restrictions. Among the serious acute respiratory effects of water pipe smoking on the respiratory system that have been reported in in literature are acute eosinophilic pneumonia, acute carbon monoxide poisoning, increase in respiratory rate, transmission of infection, and acute deterioration in lung function. Among the long-term effects are the increased risk of lung cancer, chronic obstructive lung disease, asthma and asthma exacerbations, and long-term effects on lung function. The impact of water pipe smoking on the respiratory system and on human health in general deserves more attention from researchers and health policy makers.

Keywords: Lungs, respiratory system, smoking, water pipe

Introduction

Origin and nomenclature

There has been a considerable controversy regarding the origin of water pipe smoking. While some believe its origin can be traced back to ancient India when it was invented by a physician Hakim Abul Fath during the reign of Emperor Akbar as a less harmful method of tobacco use, others suggest that it was first used in South Africa, Persia, Ethiopia, and other countries. The latter belief was supported by the fact that more ancient traces of water pipe smokes were found in Southern or Eastern Africa.[1-3] Regardless of its origin, trade routes seem to have helped disseminate the practice throughout parts of Asia and the Middle East.[4] Water pipe smoking has been recognized in different countries by different names.[5] Many of these names are of Indian, Turkish, Uzbek, Persian, or Arab origin. "Narghile" (a name commonly used in Turkey, Lebanon, Syria, Greece, and Palestine) is derived from the Persian word nārgil or "coconut." "Shisha" is from the Persian word shishe or "glass." "Hashishe" is also an Arabic word for grass, which may have been another way of saying tobacco. Hookah is an Arabic name, meaning a small box, pot, or jar. Both names refer to the original methods of constructing the smoke/water chamber part of the hookah. "Shisha" is the name that is more commonly used in Egypt. In Iran, it is called ghalyoun or ghalyan and in Pakistan it is referred to as huqqa.[5]

Structure of a water pipe

Modern water pipes used for tobacco smoking are made from different parts [Figure 1]: the head, where the tobacco and the charcoal are placed, the bowl that is usually half-filled with water, the stem that connects the head and the bowl, and the hose where the smoke exits the pipe to the mouth of the smoker. A disposable mouth piece is usually attached to the hose. Tobacco used in water pipe is usually a flavored one called "meassel" or "maassel" (derived from Arabic name "honey" because of its moist and sweet flavor). The flavored tobacco is placed at the head and covered with aluminum foil that is

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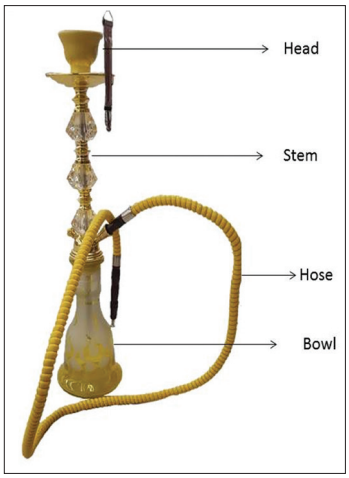

Figure 1: Structure of the modern water pipe used for tobacco smoking

punctured to make small holes. A lightened piece of charcoal is then placed over the foil. When the person inhales through the hose, a low pressure is created inside the bowl that causes the water in the bowl to rise and hence allowing the smoke to flow from the head part to the bowl through the stem. Smoke bubbles exit the end of the stem to the water and then leave the water surface to accumulate in the empty half of the bowl. The smoking person keeps inhaling the tobacco smoke from the bowl through the hose. An excess of 22 different flavors of water pipe tobacco are available in the market such as blueberry, grape, mint, apple, etc., [Figure 2].

Rising prevalence of water pipe smoking

Tobacco use has become a global major health problem and a leading global cause of preventable death. It kills nearly 6 million people and causes hundreds of billions of dollars of economic damage worldwide each year. Most of these deaths occur in low- and middle-income countries.[6] About 49% of men and 11% of women in the low- and middle-income countries smoke a tobacco product. A study of about 3 billion individuals aged 15 years or older living in 16 countries estimated that 852 million are tobacco users, including 301 million in China and 275 million in India.[7] Time trends among 13–15 year olds show that while cigarette smoking has been either stable or declining globally, water pipe smoking is on the rise in many countries and is replacing cigarettes as the most popular method of tobacco use among Middle Eastern youths. As the epidemic progresses, the water pipe's spread among adults globally is increasingly documented.[8-11] A systematic review conducted by Akl *et al*. found that the highest prevalence of current water pipe smoking was among school students across countries: the United States, especially among Arab Americans (12%–15%), the Arabic Gulf region (9%–16%), Estonia (21%), and Lebanon (25%). Similarly, the prevalence of current water pipe smoking among university students was high in the Arabic Gulf region (6%), the United Kingdom (8%), the United States (10%), Syria (15%), Lebanon (28%), and Pakistan (33%).[12] In their systematic review, Akl *et al*. also found that the prevalence of current water pipe smoking among adults was as follows: Pakistan (6%), Arabic Gulf region (4%–12%), Australia (11% in Arab-speaking adults), Syria (9%–12%), and Lebanon (15%). Group water pipe smoking was high in Lebanon (5%) and Egypt (11%–15%). In Lebanon, 5%–6% of pregnant women reported smoking water pipe during pregnancy.[12] The popularity of water pipe smoking has rapidly spread to Western nations. Recent studies have shown a prevalence of as high as 8.5% among adults in certain European countries such as Denmark and Cyprus.[10,13] In fact, among the young adults of the United States, water pipe smoking is becoming the second most prevalent of alternate tobacco products after cigarette smoking.[14] Many experts have declared the problem in Western countries as an "emergent health crisis"[15] or as an "emerging deadly trend."[16]

Factors promoting water pipe smoking

Several factors are responsible for the spread and promotion of water pipe tobacco smoking, including the sweetened and flavored water pipe tobacco, the social media that promotes this method of tobacco use, and the misperceptions about its addictive potential and adverse health effects.[13] A cross-sectional study conducted by Abdulrashid *et al*. to address the reasons for addiction to water pipe smoking and study in depth the factors contributing to the increase in its frequency among Saudi females found that most of the participants believed that water pipe smoking was less harmful and less addictive than cigarette smoking. Among the other reasons that led to unintentional dependency on water pipe smoking were peer pressure, view that it is a fashion symbol, improved mood, and effect of the weather.[17] A recent study from the United States found that college students have low negative perceptions of the health risks (addictive and detrimental properties) of hookah use.[18] A very recent systematic review that addressed the knowledge, attitudes, and perceptions toward water pipe tobacco smoking among college or university students found several reasons for initiation of water pipe smoking among this group, including curiosity, peer/social influence, wanting to overcome the social anxiety, a belief that water pipe smoking is popular among peers or is a socially acceptable form of tobacco smoking that retains a certain prestige, and the belief that it is more socially acceptable than cigarettes. Among the most common reasons associated with continued water pipe smoking were the opportunity to socialize; the opportunity to be fun, pleasurable, attractive, and relaxing; media portrayal; and the belief that water pipe smoking is less harmful than cigarette smoking. Repeatedly, participants noted the pleasant taste and aroma of water pipe smoking as a major factor behind their use of water pipe.[19]

Materials and Methods

This was a narrative, nonsystematic review to explore the impact of water pipe smoking on the respiratory system. A literature search was conducted without date restrictions using the following online databases (PubMed, PMC, Google Scholar, EMBASE, and ScienceDirect) with the following search terms: "water pipe," "hookah," "shisha," "narghile,"

Figure 2: Different water pipe tobacco flavors

"narguile," "water-pipe," "respiratory system," "lung," "lung function," and "cancer," in various combinations. Retrieved records were reviewed, summarized, and divided into two main categories: acute effects and long-term effects. Only articles published in English, regardless of the type of study used, were included in the review process. All authors were involved in the search, review, and summarizing processes. WM and WI wrote the manuscript draft that was read and approved by all authors. No statistical analysis was performed on the original data. All authors approved the final version.

Results

Mechanisms of water pipe smoking-induced lung injury

Contrary to popular perceptions, water pipe smoking contains many harmful and potentially harmful constituents (HPHCs) such as nicotine, particulate matter, carbon monoxide (CO), volatile organic compounds, polycyclic aromatic hydrocarbons, heavy metals, and arsenic. The profile of these toxic chemicals in water pipe smoke is thought to be similar to the smoke of combustible cigarettes. Nevertheless, important differences in HPHC profiles of water pipe smoke that make it even higher than those of cigarettes have been recognized. These differences include the additional use of charcoal to heat the tobacco, the temperature at which the tobacco is heated or burned, and the volume of delivered smoke.[13] In fact, some studies have reported that a single water pipe use session emits in the sidestream smoke approximately four times the carcinogenic polyaromatic hydrocarbons, four times the volatile aldehydes, and 30 times the CO of a single cigarette. During a typical 1-h water pipe use session, a water pipe smoker can generate ambient carcinogens and toxicants equivalent to 2–10 cigarette smokers.[20] With a standard smoking protocol of 100 puffs of 3 s duration spaced at 30-s intervals, a single mainstream smoking session causes inhalation of 2.25 mg nicotine; 242 mg dry particulate matter; and higher levels of arsenic, chromium, and lead compared to smoking a single cigarette.[21] Studies have also shown that water pipe tobacco users and nonsmoking employees of water pipe venues had higher urinary concentrations of several toxic metals including manganese and cobalt as well as of volatile organic compounds, in a distinct signature compared to cigarette smoke.[22] As many of these chemicals are toxic to the lungs, several studies have examined the toxic effects of water pipe smoking on the lungs. Khabour *et al*. examined the effects of acute exposure of water pipe smoking on lung inflammation and oxidative stress in mice and compared them to cigarette smoking. Mice were divided into three groups: fresh air control, cigarette, and water pipe. Animals were exposed to fresh air, cigarette, or water pipe smoke using whole-body exposure system 1 h daily for 7 days. Both cigarette and water pipe smoke exposure resulted in elevation of total white blood cell count, as well as absolute count of neutrophils, macrophages, and lymphocytes ($P < 0.01$). Both exposures also elevated proinflammatory markers such as tumor necrosis factor-α (TNF-α) and interleukin (IL)-6 in bronchoalveolar lavage fluid (BAL) ($P < 0.05$) and oxidative stress markers including GPx activity in the lungs ($P < 0.05$). Moreover, water pipe smoke increased catalase activity in the lung ($P < 0.05$). However, none of the treatments altered IL-10 levels.[23] Similarly, in a more recent study, Nemmar *et al*. demonstrated a substantial increase in inflammatory cell infiltration in the peribronchiolar and interstitial spaces (formed predominantly out of neutrophil polymorphs) on pathologic lung sections of mice exposed to water pipe smoking. Water pipe smoking also caused a significant augmentation in the TNF-α concentration in lung homogenates, significant increase in 8-isoprostane concentrations, significant increase in DNA migration, and slight and insignificant increase in Nrf2 expression in the lung. Airway resistance was significantly and dose dependently increased in water pipe-exposed mice.[24] A number of studies have also demonstrated the genotoxic effects of water pipe smoking. Derici Eker *et al*. collected peripheral blood/buccal smear samples from 30 individuals who did not smoke cigarettes but who regularly smoke an average of two times per week hookah and from 30 controls who had never smoked cigarettes or hookah. Chromosomal analyses were performed on the samples obtained from peripheral blood of each individual. The study revealed significant statistical differences between the individuals who smoked hookah and those who did not in terms of fragment, gap, micronucleus, and binucleus parameters, suggesting that smoking a hookah may

cause genotoxic effects.[25] Similar genotoxic effects and DNA damage have also been reported in other studies.[26] Moreover, Kaddah *et al*. compared the hazardous effects of smoking water pipe to that of cigarette, by the estimation of matrix metalloproteinase (MMP-2 and MMP-9) gene expression in BAL of 32 patients with chronic obstructive pulmonary disease (COPD). The authors concluded that smoking shisha induces expression of metalloproteinases in BAL as much as in smoking cigarettes.[27]

Acute effects on the respiratory system

Acute eosinophilic pneumonia

Acute eosinophilic pneumonia (AEP) is an uncommon acute respiratory illness characterized by acute febrile respiratory failure, diffuse bilateral infiltrates on chest radiograph, and eosinophilia in BAL fluid, in the absence of infection or alternative causes for eosinophilia. The disease can lead to serious respiratory complications, and early diagnosis and treatment with corticosteroids is essential, because the prognosis is excellent if corticosteroid therapy is instituted promptly. Nevertheless, despite the excellent response to corticosteroids, the diagnosis is often delayed, and patients may progress to hypoxic respiratory failure. AEP may be idiopathic, but identifiable causes include smoking and other inhalational exposures, medications, and infections. Of all inhalational causes of AEP, cigarette smoking has been the most frequently implicated trigger in recent years. Individuals who start smoking or resume smoking after cessation are at particular risk.[28] The pathogenesis of AEP is incompletely understood. AEP may represent an acute type I hypersensitivity reaction triggered by the presentation of an offending agent (for example, cigarette smoke or an infectious pathogen) by alveolar macrophages.[28] Serious forms of AEP in association with water pipe smoking have been reported in the literature. Among the four cases of AEP associated with water pipe smoking reported in literature, three cases required intubation and mechanical ventilation for up to 7 days.[29-32] A fourth case required extracorporeal membrane oxygenation for 7 days after mechanical ventilation failed.[33] AEP therefore, should be a diagnostic consideration in any patient with recent water pipe smoking who develops acute respiratory illness.

Acute carbon monoxide poisoning

CO poisoning results in an estimated 50,000 emergency department visits in the United States annually[34,35] and is one of the leading causes of poisoning death. CO produces hypoxia by binding with hemoglobin, reducing the oxygen-carrying capacity of the blood, and producing hypoxia in the tissues.[34] CO also shifts the oxyhemoglobin curve to the left, which further reduces tissue partial pressure of oxygen. The diagnosis of CO poisoning is a clinical one: the common definition requires a history of recent CO exposure, the presence of symptoms consistent with CO poisoning, and demonstration of an elevated carboxyhemoglobin level. The most common symptoms included headache, dizziness, nausea/vomiting, confusion, fatigue, chest pain, shortness of breath, and loss of consciousness.[34,36] The typical "Cherry red" skin coloring in patients with CO poisoning is rare and its absence should not exclude the diagnosis. As symptoms are nonspecific, a high index of suspicion is warranted. Failure to diagnose CO poisoning can have disastrous health consequences. High-flow oxygen by mask or endotracheal tube is the front-line treatment. Oxygen accelerates the elimination of carboxyhemoglobin and alleviates tissue hypoxia compared with air. Hyperbaric oxygen should at least be considered in all cases of serious acute CO poisoning and normobaric 100% oxygen should be continued until the time of hyperbaric oxygen administration.[34,37] A number of factors can explain the increasing risk of CO poisoning among water pipe smoking: the longer duration a water pipe smokers can smoke compared to cigarette smokers, the deep inhalation because of the less irritating nature of the moisturized smoke, the use of charcoal, and the fact that water in the water pipe filters only a small portion of the noxious substances. All these factors can cause water pipe smokers to absorb higher concentrations of CO than cigarette smokers.[38,39] In a study of 62 volunteers, a single session of water pipe smoking for 30 min resulted in increase of carboxyhemoglobin concentration by eight-fold in active smokers, by 25% in six individuals, and by 40% in two individuals. In passive smokers, post-water pipe smoking, carboxyhemoglobin levels increased by 50%.[40] In a recent retrospective cohort study of 61 individuals with CO poisoning related to water pipe smoking, most of the patients were young adults with a mean age of 23 (standard deviation [SD] ±6) years. A wide variability of symptoms was reported ranging from none to unconsciousness. The initial mean carboxyhemoglobin was 26.93% (SD ± 9.72). The most common symptoms included syncope, dizziness, headache, and nausea. About 75% of individuals had temporary syncope and the symptoms were not closely associated with blood carboxyhemoglobin levels.[41] Furthermore, a number of case reports describing CO poisoning in water pipe smokers have been published in literature. Most of the patients reported were in the young age group ranging from 16 to 25 years old. Carboxyhemoglobin levels in all these cases ranged from 24% to 30%. Majority of patients were treated with oxygen supplementation and did well clinically. One patient was treated with hyperbaric oxygen because of the patient's loss of consciousness and transient neurologic symptoms.[38,42-45]

Effects on the respiratory rate

In a comparative study evaluating the acute effects of active and passive indoor group water pipe smoking on various clinical and laboratory parameters, Bentur *et al*. found that a session of active indoor group water pipe smoking resulted in significant increase in respiratory rate in both active (from 16.2 to 19.7; $P = 0.0001$) and passive smokers (from 16.25 to 20.5; $P = 0.009$).[40] Hakim *et al*., in a prospective study of 45 volunteers who were subjected to 30-min session of water pipe smoking, also reported a significant increase in the respiratory rate postsmoking (from 14.36 to 16.68 breaths/min; $P = 0.001$).[46] Similar effects have also been reported by Shaikh *et al*.[47] and Toukan *et al*.[48]

Risk of transmission of respiratory infections

The increased risk of transmission of infectious microbial agents through smoking water pipes can be explained by a number of reasons. First, the moisture in water pipe hose promotes the growth of microorganisms. Second, smokers frequently cough into hoses. Third, many water pipe smokers share their water pipe with others during smoking session. Sharing a water pipe may contribute to the spreading of tuberculosis (TB), mononucleosis, viruses, and bacteria. Moreover, most cafés tend not to clean the water pipes after each smoking session because washing and cleaning water pipe parts is labor-intensive and time-consuming.[49-52] The association between cigarette smoking and the increased risk of active TB has been reported by multiple investigators. Lin *et al*. from Taiwan found a significant association between current smoking and the increased risk of active TB (adjusted odds ratio [OR]: 1.94). The association was stronger among those <65 years of age than those >65 years of age.[53] A prospective cohort study of over 1.3 million South Koreans reported that male current cigarette smokers had a 40% increased risk of incident TB compared with nonsmokers and were 55% more likely to die of TB. Former smokers, both males and females, were also found to be at increased risk of TB mortality and incidence. Smokers also had greater risk of recurrence.[54] Nevertheless, studies that address the association between TB and water pipe smoking in particular are scarce. In 2001, new cases of pulmonary TB were noted in a cluster of young Caucasian males, an unusual ethnic group for this disease in Queensland, Australia. It was noted that marijuana water pipe ("bong") smoking was common among cases and contacts. To investigate whether shared use of a marijuana water pipe was associated with transmission of TB, Munckhof *et al*. studied the contacts who shared a marijuana water pipe with TB cases. Although the most important risk factor for acquiring TB infection in that cluster was close household contact with a case, sharing a marijuana water pipe with a case of pulmonary TB was associated with transmission of TB (OR: 2.22).[49] In a study of *Helicobacter pylori* infection in 210 individuals, El-Barrawy *et al*. found a significant correlation between *H. pylori* infection and the communal use of water pipe smoking.[55] Szyper-Kravitz *et al*. reported a patient with acute myeloid leukemia with invasive pulmonary aspergillosis who acquired the infection from using water pipe. Cultures from the water pipe yielded heavy growth of *Aspergillus* species.[56] Other pathogens that could potentially be transmitted include hepatitis C, herpes simplex, Epstein–Barr virus, respiratory viruses, and human immunodeficiency virus.[39] Following the emergence of the Middle East respiratory syndrome coronavirus (MERS-CoV) in the Kingdom of Saudi Arabia, Alagaili *et al*. investigated the role of water pipe smoking in the transmission of the virus causing the disease. A total of 2489 water pipe samples were collected from cities where the MERS-CoV cases were continuously recorded. Although the MERS-CoV RNA was not detected in any of the collected samples, the authors anticipated the possibility of such transmission and recommended the replacement of reusable hoses with "one-time-use" hoses in addition to proper cleaning and sanitization of water pipe component.[50]

Acute effects on pulmonary function tests

Multiple studies have evaluated the acute effects of water pipe smoking on pulmonary function test (PFT). Among the acute effects that have been documented are the reductions in peak expiratory flow rate (PEFR) and the forced expiratory flow 25%–75% (FEF 25%–75%). Nevertheless, studies on the acute effects on other spirometric parameters yielded inconsistent results. Hakim *et al*. investigated the short-term effects of 30-min water pipe smoking session on the PFT. The study showed that one session of water pipe smoking resulted in significant reduction in PEFRs, the levels of FEF 25%–75%, and the fraction excretion of nitric oxide in the exhaled air (FeNO).[46] Similarly, Hawari *et al*. reported a significant reduction in FEF 25%–75% from 5.51 to 5.29 L.[57] Bentur *et al*. studied the acute effects of 30-min water pipe smoking in both active and passive smokers on PFT. No change was found in forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), FEV1/FVC, and FEF 25%–75% after active indoor group water pipe smoking. However, a minor decrease in PEFR, which became insignificant after applying Bonferroni correction, was observed. No change was found in PFT after passive water pipe smoking.[40] Layoun *et al*. studied spirometric parameters before and 45 min after the beginning of water pipe smoking in Lebanon. A postsmoking decrease in actual FEV1/predicted FEV1 of 1.21 ± 8.7 was observed in water pipe smoking.[58] The acute effects of water pipe smoking on oxygen saturation in the blood have seldom been studied. In a cohort study from Kuwait, Al-Osaimi *et al*. evaluated the acute effects of water pipe smoking on arterial oxygen saturation comparing baseline oxygen saturation to that following a 30-min session of water pipe smoking. Postwater pipe smoking session, oxygen saturation significantly decreased by 0.39%.[59]

Long-term effects on the respiratory system

Long-term effects on pulmonary function test

Unlike the acute effects, the long-term effects of water pipe smoking on PFT have been well studied and consistent with most of the studies. In a recent study of the effects of water pipe smoking on PFT and FeNO among Saudi young adult water pipe smokers, Meo *et al*. found a significant decrease in PFT parameters including FEV1, FEV1/FVC ratio, FEF 25%, FEF 50%, FEF 75%, and FEF 75%–85% among shisha smokers relative to their control group. There was also a significant reduction in the FeNO among shisha smokers compared to the control group.[60] In a meta-analysis of six cross-sectional studies on the long-term effects on PFT, Raad *et al*. found that water pipe smoking was associated with a statistically significant reduction in FEV1 (equivalent to a 4.04% lower FEV1%), a trend toward lower FVC (equivalent to a 1.38% reduction in FVC%), and lower FEV1/FVC (equivalent to a 3.08% lower FEV1/FVC) compared to nonsmokers.

Comparing water pipe smoking with cigarette smoking, there was no statistically significant difference in FEV1, FVC, and FEV1/FVC.[61] An interesting study that compared the PFT parameters in water pipe smokers, cigarette smokers with deep inhalation, cigarette smokers with normal inhalation, and nonsmokers found that all PFT values were significantly lower in water pipe smokers and cigarette smokers with deep inhalation compared to nonsmokers. In addition, all PFT values in water pipe smokers and cigarette smokers with deep inhalation were lower than corresponding values in cigarette smokers with normal inhalation except for FEV1 and FEF 25%.[62] Interestingly, some studies compared PFT in water pipe smokers and cigarette smokers. Ben Saad *et al*. compared the PFT of exclusive water pipe smokers to those of exclusive cigarette smokers. The two groups were well-matched in terms of age, height, and quantities of tobacco smoked. Compared to the exclusive water pipe smoker group, the exclusive cigarette smoker group had significantly lower FEV1 (84 vs. 60%), FVC (90 vs. 76%), and FEV1/FVC (99 vs. 83%). The two groups had similar percentages of restrictive ventilatory defect (31 vs. 36%), whereas the exclusive cigarette smokers group had a significantly higher percentage of obstructive ventilatory defect (8 vs. 58%) and lung hyperinflation (36 vs. 57%).[63] Kiter *et al*. performed PFT on 397 males who were divided into four groups: water pipe smokers, water pipe smokers who used to smoke cigarettes, active cigarette smokers, and nonsmokers. When compared with nonsmokers, statistically significant decreases in PEFR of water pipe smokers and in PEFR, FEF 25%, and FEV1/FVC of water pipe smokers who quit cigarette smoking were found. The authors also reported small airway obstruction to be more significant in cigarette smokers than water pipe smokers when compared to nonsmokers.[64] In a cross-sectional study, Ben Saad *et al*. compared 6-min walk distance test (6MWD) in exclusive water pipe smokers and healthy nonsmokers. The exclusive water pipe smoker subgroup had a significantly lower 6MWD (87% vs. 98% predicted; $P = 0.001$). The authors considered this reduction in submaximal exercise as an early sign of the progressive negative impact of water pipe smoking.[65]

Risk of lung cancer

Most of the studies that evaluated the association between water pipe smoking and the risk of lung cancer are case–control studies and few are retrospective studies. Lubin *et al*. carried out a population-based case–control study of 427 male lung cancer patients residing in a mining area of Southern China and 1011 controls to address the association of water pipe smoking with lung cancer. Of these patients, 63% smoked cigarettes and (water and long stem) pipes; 17% and 14% smoked only cigarettes or pipes, respectively; and 6% did not smoke. Compared to nonsmokers, smokers of cigarettes only, smokers of pipes only, and mixed smokers were at increased risk of lung cancer; OR: 2.6, 1.8 and 4.1 respectively. Risk increased with duration of tobacco use.[66] A hospital-based case–control study was conducted by Aoun *et al*. in Lebanon to assess the possible risk factors for lung cancer. The study showed an important association of water pipe smoking with lung cancer in the bivariate analysis. An excess of lung cancer risk was found in water pipe smokers compared with nonsmokers.[67] In a study from Kashmir, Koul *et al*. found hookah smoking to be associated with a significantly higher risk for lung cancer, with about six-fold elevated risk as compared to nonsmoking controls.[68] Gupta *et al*. conducted a retrospective study on 265 (235 men and 30 women) histologically confirmed patients of lung cancer and 525 hospital controls matched for age and sex. The study participants were interviewed according to a predesigned questionnaire. Smoking of bidi and hookah as well as cigarettes had similar ORs for cumulative consumption for lung cancer risk.[69] A systematic review and meta-analysis reported a significant association between water pipe smoking and lung cancer with an OR of 2.12.[70]

Risk of chronic obstructive pulmonary disease

Several cross-sectional studies from various countries documented the association between water pipe smoking and COPD and water pipe smoking and chronic bronchitis. Salameh *et al*. studied 211 COPD cases and 527 controls. The study showed a high OR between the risk of developing COPD and being an ex-smoker of water pipe or a current water pipe-dependent individual. The ORs were 11.7; ($P < 0.001$) for previous water pipe smoking and 44.1; ($P < 0.001$) for previous mixed smoking. In current smokers, the ORs were 1.8; ($P = 0.299$) for water pipe smoking and 9.4; ($P < 0.001$) for mixed smoking. Moreover, they found, in water pipe current smokers, an OR of 8.9; ($P < 0.001$) for the association between dependence and COPD. These results were confirmed by stratified and multivariate analysis, after adjustment for cigarette smoking and confounding variables. A cumulative smoking of one water pipe per week for 20 years (or its equivalent) was predictive of higher risk of COPD.[71] In a study of COPD prevalence in Lebanon, Waked *et al*. reported the prevalence by smoker subgroup. The highest prevalence was found in mixed smokers (31.1%), followed by cigarette smokers (16.5%), water pipe smokers (6.7%), and, finally, never smokers (3.4%; reference category). Moreover, a significant dose–effect relationship was found for both cigarettes and water pipes: COPD prevalence increased from 5.2% in noncigarette smokers to 7.3% in cumulative smokers of <15 pack-years, 13.7% if cumulative smoking was between 15 and 45 pack-years, and 34.3% if cumulative smoking was higher than 45 pack-years ($P < 0.001$ for trend). For cumulative water pipe smokers, COPD prevalence was 11.3% in nonwater pipe smokers, 11.6% in smokers of <15 water pipe-years, 18.2% if cumulative smoking was between 15 and 40 water pipe-years, and 37.2% if cumulative smoking surpassed 40 water pipe-years ($P < 0.001$ for trend).[72] In a study from Syria, Mohammad *et al*. found chronic bronchitis to be more prevalent in water pipe smokers than cigarette smokers, either for cumulative quantity or for duration.[73] In the BREATHE study, the association between water pipe use and COPD symptoms was determined after adjusting for cigarette consumption. A significant association was observed

for all respiratory symptom clusters including productive cough, chronic bronchitis, and breathlessness ($P < 0.026$). For both cigarette smoking and water pipe use, the association was most robust for chronic bronchitis and weakest for breathlessness.[74] She *et al*. in a multicenter, cross-sectional study enrolled 1238 individuals from 10 towns in China. A matched design was used to estimate the impact of active and passive exposure to Chinese water pipe smoking on COPD risk (Chinese water pipe tobacco smoking was thought to be less harmful under the assumption that no charcoal is used and water filters tobacco smoke). The increased risk of COPD was profound for Chinese water pipe smokers (adjusted OR: 10.61), Chinese water pipe passive smokers (adjusted OR: 5.5), cigarette smokers (adjusted OR: 3.18), and cigarette passive smokers (adjusted OR: 2.52) compared with never-smoking controls.[75] A recent systematic review and meta-analysis found a significant association between water pipe smoking and chronic COPD and water pipe smoking and chronic bronchitis. The pooled OR for the association of water pipe tobacco smoking and COPD was 3.18, and the pooled OR for the association of water pipe tobacco Smoking and bronchitis was 2.37.[70]

Risk of asthma

Several studies and systematic reviews have confirmed the effect of active tobacco smoking on the risk of asthma in adults as well as the effects of active and passive smoking on the risk of asthma exacerbations.[76-83] A recent comprehensive systematic review and meta-analysis of all these studies reported that smokers were 1.61 times more likely to develop asthma, and adult smokers are 1.71 times more likely to have asthma exacerbations. It was also found that pregnant women with asthma who smoked had more asthma exacerbations per year and poorer asthma control, and children exposed to passive smoke were more than twice as likely to have multiple hospital admissions.[84] Furthermore, some studies addressed the effects of water pipe smoking in particular. Waked and Salameh found that water pipe smoking by the mother is consistently and independently associated with all types of allergic diseases, including asthma symptoms, allergic rhinitis, and atopic dermatitis in childhood.[85]

Conclusions

Although ample evidence has shown that water pipe smoking can cause several acute and long-term effects on the respiratory system, the epidemic of water pipe smoking continues to rise particularly among youths. There is a high level of unawareness and misconception about the harmful effects of water pipe smoking. More efforts from public health policy makers, national tobacco control programs, and health-care professionals are needed to combat such rising epidemic of water pipe smoking. Some of these efforts may include implementation of policy changes to decrease the water pipe smoking initiation by increasing water pipe smoking taxes, control policy for water pipe smoking labeling, water pipe apparatus labeling, mandatory health messages in hookah cafes, and location and distance restriction for hookah cafes from schools and colleges.[86] Educational programs such as mass media campaigns, comprehensive community programs, and school-based programs can also be some of the most effective strategies in changing social norms and preventing youth water pipe smoking.[87]

Authors' contributions

WM and WHI conceived the idea of the review. All authors provided their designated sections and critically revised the rest of the manuscript for intellectual content, language, and presentation. All authors approved the final version of the article.

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Conflicts of interests

There are no conflicts of interest.

Compliance with ethical principles

No ethical approval is required.

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