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EVIDENCE BRIEF

Health Impacts of Waterpipe Smoking and Exposure

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Key Messages

- Waterpipe smoke from both tobacco-based products and non-tobacco "herbal" products contains harmful toxins and chemicals, such as particulate matter (PM), polycyclic aromatic hydrocarbons (PAHs), carbon monoxide (CO) and heavy metals.

- There is an association between waterpipe smoking and adverse respiratory health outcomes including chronic obstructive pulmonary disease (COPD), chronic bronchitis and impaired nasal mucociliary clearance. Both waterpipe smoking and secondhand exposure to waterpipe smoke are significantly associated with increased coughing/wheezing.

- Waterpipe smoking is positively associated with acute negative cardiovascular effects (e.g., elevated heart rate [HR] and blood pressure [BP], compromised autonomic regulation, reduced exercise capacity) and chronic cardiovascular effects (e.g., coronary artery disease [CAD], heart disease, and metabolic syndrome).

- Waterpipe smoking is positively associated with lung cancer and there is some evidence that waterpipe smoking is also positively associated with overall cancer mortality. Mixed results were found for the associations between waterpipe smoking and head and neck, gastric, liver and bladder cancers. No significant association was found between waterpipe smoking and prostate, pancreatic or colorectal cancers.

- Smoking waterpipe tobacco during pregnancy has been found to significantly increase the risk of low birth weight. Other potential adverse outcomes associated with waterpipe smoking during pregnancy include newborn and childhood respiratory problems, sudden infant death syndrome, and potentially long term childhood memory, learning, emotional and behavioural development challenges.

- Both waterpipe and cigarette smoking are harmful with many similar health effects. Waterpipe smokers have been found to have higher levels of triglycerides and higher mean HR and BP compared to cigarette smokers. It was also found that waterpipe smoke contains increased levels of select harmful toxicants compared to cigarette smoke. While concurrent use of cigarettes and waterpipe is not uncommon, evidence investigating impacts of waterpipe smoking independent of cigarette smoking supports its association with adverse health outcomes such as chronic bronchitis, CAD and CO poisoning.

- Apart from the known detrimental effects of waterpipe smoke, the practice of smoking and sharing a waterpipe may lead to the spread of infectious pathogens due to inadequate cleaning between smokers. Effectiveness of disposable mouth pieces is undetermined and transmission of infectious pathogens may be possible via contamination of the hose or water bowl, which are typically cleaned less often and are more challenging to clean effectively.

- Non-smoking sections of waterpipe cafes have been found to have similar levels of harmful toxins in the air as restaurants where cigarettes are smoked; separate dedicated areas for waterpipe smoking within an establishment do not eliminate the risk to non-smokers.

Issue and Research Question

Waterpipe smoking, also referred to as “shisha” or “hookah”,[1] has traditionally been used in Asian and eastern Mediterranean regions,[2] but in recent years this custom has grown in popularity across the globe, particularly among youth.[2-4] Waterpipe smoking involves heating a tobacco or non-tobacco “herbal” product using charcoal or an electronic heat source that creates smoke.[1,5,6] Users inhale through a hose attached to the waterpipe device, which draws the smoke from the product (tobacco or non-tobacco) first through the waterpipe shaft, then through a water chamber and finally through the hose to be inhaled by the user.[1,6]

The rise in popularity of waterpipe smoking is believed to be attributed to various factors. First, there is a misconception that waterpipe smoking is a safer form of tobacco smoking.[2,4,7] Second, the custom of waterpipe smoking is generally a social event and therefore socially accepted.[4,7] Third, various waterpipe products available include fruity flavours and nicotine-free products, which may contribute to the

perception of these products being less harmful and more appealing than other types of smoking.[7] Lastly, there is a lack of legislation related to waterpipe smoking.[2,7] The *Smoke-Free Ontario Act* prohibits the use of tobacco in waterpipes in restaurants and bar patios; however, the use of non-tobacco products in waterpipes is still permitted.[8]

Despite its long history and increasing prevalence, relatively little is widely known about the health risks associated with waterpipe exposure.[1,2,4] The primary purpose of this evidence brief is to examine review-level evidence regarding the health effects from the use of, and exposure to, tobacco and non-tobacco waterpipes. In addition, four areas of consideration are also highlighted in relation to the use of, and exposure to, waterpipes: (1) cultural considerations; (2) disposable pipes and filters; (3) room configuration; and (4) ventilation.

Methods

A literature search was conducted in July 2021 by PHO Library Services for articles published from 2015 onwards. The search was limited to 2015 onwards to expand upon the existing evidence synthesis conducted by the Region of Peel in 2015.[6] The search involved four databases: Ovid MEDLINE, Ovid Embase, EBSCOhost Environment Complete and EBSCOhost CINAHL Complete. Search terms included, but were not limited to: hookah, waterpipe, smoking, general health, cancer, heart disease, mouth disease, pregnancy, disease transmission and environmental exposure. The full search strategy is available upon request.

Articles were eligible for inclusion if they: were review-level, assessed any health outcomes of exposure to or use of waterpipes and were published in English in 2015 or later. Reviews were excluded if they were duplicates, non-review level (also excluded “reviews” summarizing literature but with no search methods reported) or assessed the use of drugs in waterpipes.

One reviewer screened the titles and abstracts of all library search results and 20% of results were randomly selected to be screened independently by a second reviewer, with any discrepancies resolved through discussion. Full texts of eligible titles and abstracts were retrieved and screened for eligibility by one of two reviewers and 20% of full texts were randomly selected to be screened independently by both reviewers. Consensus on included studies was achieved through discussion. Relevant findings were extracted from each article independently in duplicate related to waterpipe exposure and health outcomes, with discrepancies resolved through discussion.

For each included review, quality appraisal was completed independently in duplicate (with discrepancies resolved through discussion) using the Health Evidence Quality Assessment Tool.[9] More information on quality appraisal is available by request.

Main Findings

A total of 211 records were retrieved from library searches, from which 73 articles were included for full-text review after title and abstract screening. In the end, 32 reviews met the inclusion criteria and were included in this evidence brief after full text screening. The reviews included studies with varied designs and methods for assessing waterpipe smoking or exposure to secondhand smoke from waterpipes and health outcomes. Twenty-two articles exclusively examined waterpipe smoking and secondhand exposure to waterpipe smoke,[1-5,7,10-25] whereas 10 articles examined smoking in general with a subsection in the results focused on waterpipe smoking or secondhand waterpipe smoke exposure.[26-35] In the latter, only evidence specifically discussing waterpipes was extracted. Twenty-two

articles assessed a focused health outcome,[1,2,4,5,7,10-13,15,16,19,20,25-27,29,31-35] seven articles assessed multiple health outcomes[3,17,18,21,24,28,30] and three articles assessed health effects as well as air pollution/smoke content.[14,22,23] All but six reviews[5,12,16,26,27,33] presented results using a comparison group such as cigarette smokers or non-smokers. Finally, seven reviews included meta-analyses.[1,3,4,10,15,27,34] Using the Health Evidence Quality Assessment Tool, nine reviews were rated as strong,[1-4,7,19,27,29,35] nine rated as moderate[10,11,15,17,20,24,25,33,34] and 14 rated as weak.[5,12-14,16,18,21-23,26,28,30-32]

Observed health outcomes ranged from cancers, biomarkers, oral health, cardiovascular effects, respiratory effects, perinatal outcomes, infectious disease, and air quality, among others. Health effects of waterpipe smoking or secondhand exposure to waterpipe smoke identified in the review literature published from 2015 onwards are summarized below.

Cancer

Fourteen articles reviewed the association of waterpipe smoking with various types of cancers.[1-4,7,16-18,20,21,24-26,34] Five reviews were strong quality,[1-4,7] five were moderate quality[17,20,24,25,34] and four were weak quality.[16,18,21,26] Overall, the included reviews found a significant association between waterpipe smoking and lung cancer,[1,3,4,7,16,21,24] mixed results for head and neck,[1-4,7,16,17,20,21,24,25] gastric,[1,3,7,24] and bladder cancers,[1,3,4,7,17,21,24,34] and no significant associations were identified between waterpipe smoking and prostate,[1,3,7,17] pancreatic[7] and colorectal[4] cancers.

LUNG CANCER

All nine reviews investigating the impact of waterpipe smoking on lung cancer, including three strong quality meta-analyses, found positive associations.[1,3,4,7,16-18,21,24] These reviews included primary studies from Lebanon, India, China and Tunisia. A strong quality systematic review and meta-analysis by Mamtani et al. (2017) found waterpipe smoking, compared to no waterpipe smoking, was significantly associated with lung cancer in their meta-analysis of all six included case-control studies assessing this outcome (odds ratio [OR]: 3.18; 95% confidence interval [CI]: 1.87, 5.42).[4] This association remained significant when the authors analyzed only the three high quality primary studies (OR: 2.22; 95% CI: 1.24, 3.97).[4] The remaining reviews support these findings showing a positive association between waterpipe smoking and lung cancer among male and female adults with reported ORs ranging between 2.12 and 4.58.[1,3,7,16-18,21,24]

HEAD AND NECK CANCERS

The available literature presents conflicting evidence on the impact of waterpipe smoking on head and neck cancers. All reviews reporting on this outcome included primary studies conducted in several Asian, Middle Eastern, and African countries. One strong quality meta-analysis found waterpipe smoking was significantly associated with head and neck cancers based on four primary studies (OR: 2.12; 95 % CI: 1.07, 4.19).[4] When analyzing only the two strong quality primary studies assessing this outcome, the association remained significant (OR: 2.97; 95% CI: 2.26, 3.90).[4] Other strong[2] and weak quality[25] reviews assessing the association between waterpipe smoking and head and neck cancers among male and female adults (one review[2] reported the mean age of participants to be >53 years) corroborate this positive association. Conversely, a review by Montazeri et al. (2017) found no association between waterpipe exposure and head and neck cancers (OR: 0.55; 95% CI: 0.24, 1.27), however this was based on a single included primary study.[1]

The most commonly reported head and neck cancer was oesophageal cancer and the available evidence provides mixed results. A strong quality meta-analysis by Waziry et al. (2017) did not find a statistically

significant association between waterpipe smoking and oesophageal cancer (OR: 4.14; 95% CI: 0.93, 18.46)[3] and one additional weak quality review also found no significant association.[21] A meta-analysis by Montazeri et al. (2017) did find that waterpipe smoking significantly increased the odds of oesophageal cancer (OR: 3.63; 95% CI: 1.39, 9.44),[1] a finding also supported in a meta-analysis by Mamtani et al. (2017) (OR: 3.11; 95% CI: 1.26, 7.65).[4] Furthermore, Mamtani et al. (2017) found a dose-response relationship between waterpipe smoking and oesophageal cancer,[4] a finding corroborated by two additional strong quality reviews.[2,7] It is important to note that all three of these reviews reported on the same primary study in which the sample included both male and female adults with a mean age of > 60 years.[2,4,7] Other reviews support the association between waterpipe smoking and the risk of oesophageal cancer, with reported ORs ranging from 1.84 to 3.63.[16,17] Two reviews found conflicting evidence with some included studies showing an increased risk of oesophageal cancer, while another included study showed no association after adjusting for cigarette use and other confounders.[7,24] These primary studies examined the association between waterpipe smoking and oesophageal cancer in both males and females with a mean age > 60 years.[7,24]

Specific head and neck cancers reported in the literature such as oral cancer and squamous cell carcinoma were found to have positive associations with waterpipe smoking.[3,16,20,26] For example, a strong quality meta-analysis of three cross-sectional primary studies conducted in Yemen and India found a significant association between waterpipe smoking and oral cancer (OR: 4.17; 95% CI: 2.53, 6.89).[3] On the other hand, all but one review[1] investigating the effect of waterpipe smoking on nasopharyngeal cancer found no significant associations.[2,3,7,17,21,25] Montazeri et al. (2017) reports a positive association between waterpipe smoking and nasopharyngeal cancer (OR: 2.63; 95% CI: 1.61, 4.30) from a single primary study.[1]

GASTRIC CANCER

Four reviews examining the association between waterpipe smoking and gastric cancer yielded mixed results. Three of the included reviews support a positive association between waterpipe smoking and gastric cancer.[1,7,24] Two of these reviews included the same prospective cohort study (study sample included both males and females in Iran with a mean age of 53 years) which found waterpipe smokers had greater odds than non-smokers of having gastric cancer, after adjusting for cigarette smoking and other risk factors (OR: 3.4; 95% CI: 1.7, 7.1).[7,24] In contrast, one meta-analysis of two primary studies (one case-control and one prospective study, both conducted in Iran) did not find a statistically significant association (OR: 2.16; 95% CI: 0.72, 6.47) and authors reported high heterogeneity across included studies (I^2 = 61%).[3]

BLADDER CANCER

While five reviews found no association between waterpipe smoking and bladder cancer,[1,3,7,17,21] one review found mixed results[24] and one review found a weak association.[4] All reviews reported on studies conducted in Africa. Of note, the review by Mamtani et al. (2017) which found a weak association (OR: 1.25; 95% CI: 1.05, 1.51) across four primary studies from Egypt and one study from Tunisia noted the quality of the studies contributing to the meta-analysis were low.[4] One review examined the effect of intensity of waterpipe smoking on bladder cancer and found no association.[34]

OTHER CANCERS

Literature on the association between waterpipe smoking and other types of cancers was sparse. Of the available literature, significant associations were not identified between waterpipe smoking and the following cancers: prostate,[1,3,7,17] pancreatic,[7] liver[4] and colorectal.[4] These findings should be interpreted

with caution due to the small body of evidence and the varying methods across included studies. Finally, two reviews found that waterpipe smoking was associated with increased overall cancer mortality,[4,17] with one review reporting current waterpipe smoking to be associated with increased cancer mortality risk (OR: 2.51; 95% CI: 1.08, 5.82).[4]

Cardiovascular Effects

Nine reviews explored the effects of waterpipe smoking on the cardiovascular system.[3,10,11,15,17-19,21,24] Five reviews explored the association between waterpipe smoking and acute cardiovascular effects including HR and BP,[11,15,17,21,24] autonomic regulation[15,24] and exercise capacity.[11,24] Eight reviews examined the chronic cardiovascular effects of waterpipe use such as CAD,[10,15,17,18,21,24] heart disease[3,15,24] and metabolic syndrome.[3,19] All reviews reported positive associations between waterpipe use and the observed health outcomes.[3,10,11,15,17-19,21,24]

ACUTE CARDIOVASCULAR EFFECTS

Although the methods varied across the studies, all reviews reported consistent conclusions that HR, diastolic blood pressure (DBP) and systolic blood pressure (SBP) increased acutely following waterpipe smoking.[11,15,17,21,24] For example, Al Ali et al. (2020) conducted a meta-analysis on experimental studies, including both males and females with mean ages ranging from 20 to 36 years (study jurisdictions not reported), and found that one session of waterpipe smoking led to an increase in mean HR by 10.14 beat/min (95% CI: 8.41, 11.88; $p < 0.001$), SBP by 7.70 mmHg (95% CI: 5.13, 10.27; $p < 0.001$) and DBP by 4.86 mmHg (95% CI: 2.94, 6.78; $p < 0.001$).[15] The effect of waterpipe smoking on these outcomes remained statistically significant in a sensitivity analysis, which removed statistical heterogeneity.[15] Furthermore, one moderate quality review compared tobacco-based to nicotine-free waterpipe smoking among young healthy men and women in the United States (average age in one primary study was 20 years and included ages for another primary study was 18-50 years) and found little increase in HR in the nicotine-free waterpipe users suggesting that nicotine is a mediator of HR increase.[24]

Another acute cardiovascular outcome impacted by waterpipe smoking includes autonomic regulation with reported impairment of HR and BP variation and baroflex sensitivity.[15,24] El-Zaatari et al. (2015) further reported on one primary study that compared tobacco-based to nicotine-free waterpipe products and found impaired HR variability after smoking either product among men and women ages 18 to 50 in the United States.[24] Authors of this review suggest that HR variability may be affected by smoke components other than nicotine.[24]

Finally, waterpipe smoking was found to be associated with reduced exercise capacity.[11,24] For example, El-Zaatari et al. (2015) reported on a study conducted in the Middle East (country not specified) that found one waterpipe smoking session in healthy young male adults impaired VO_2 max and peak O_2 pulse (oxygen extracted per heartbeat at peak exercise) compared to measures taken after 48 hours of abstinence from waterpipe smoking: VO_2 max decreased from 1.86 to 1.7 L/min and peak O_2 pulse decreased from 10.89 to 9.97 mL/beat.[24] It was suggested that the drop in peak O_2 pulse was attributed to exposure to CO.[24]

CHRONIC CARDIOVASCULAR EFFECTS

All six reviews examining waterpipe smoking and CAD found consistent conclusions suggesting a positive association.[10,15,17,18,21,24] Al Ali et al. (2020) compared waterpipe smokers to both non-smokers and cigarette smokers and found there was no significant difference in overall cardiovascular disease incidence between waterpipe and cigarette smokers.[15] However, among CAD patients, waterpipe

smokers had greater CAD severity (measured using the Duke Jeopardy Score) compared to cigarette smokers ($p < 0.05$), and long-term waterpipe smokers were more likely than non-smokers to have severe coronary stenosis (OR: 2.94; 95% CI: 1.04, 8.33).[15] A systematic review and meta-analysis by Morovatdar et al. (2020) included studies from Iran and Lebanon, and found among male and female patients with coronary stenosis, heavier waterpipe smoking was associated with greater risk of CAD when compared to those who smoked waterpipe less often (OR: 2.001; 95% CI: 1.13, 2.87).[10] Al Ali et al. (2020) also reported on two hospital-based studies which found significant associations between waterpipe smoking and incidence of myocardial infarction (i.e., heart attack).[15]

The literature presented consistent findings on waterpipe smoking and heart disease suggesting a positive association.[3,15,24] One Iranian community-based cross-sectional study with over 50,000 adult participants (42% males) included in two reviews[15,24] found a dose-response relationship where the risk of heart disease for heavy users (defined as users with a history of >180 waterpipe-years, i.e., waterpipe smoked per day times number of smoking years) and moderate to heavy users (defined as users with >50 waterpipe-years) were OR: 3.75 (95% CI: 1.5, 9.2) and OR: 1.83 (95% CI: 1.1, 3.1), respectively, compared to low/never users (<50 waterpipe-years).[15,24]

Finally, metabolic syndrome was found to be associated with waterpipe smoking.[3,19] Baalbaki et al. (2019) reported on one cross-sectional study conducted in Pakistan (sample included men and women ages 30-75 years) that found that this association remained significant even after controlling for confounders.[19]

Respiratory Effects

Nine reviews explored the association between waterpipe exposure and respiratory outcomes.[3,17,18,21,23,24,29,30,33] Specifically, five reviews examined COPD,[3,17,18,21,24] four reviews examined bronchitis,[3,17,18,24] six reviews examined coughing/wheezing[3,17,18,21,23,30] and four reviews explored other respiratory effects.[21,24,29,33] All reviews reported consistent conclusions of a positive association between waterpipe exposure and adverse respiratory effects.[3,17,18,21,23,24,29,30,33]

CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Five reviews examined the association between waterpipe smoking and COPD.[3,17,18,21,24] Four out of five reviews found a significant association.[3,17,18,21] For example, a meta-analysis by Waziry et al. (2017) found individuals who smoke waterpipe had greater odds of having COPD compared to non-smokers (OR: 3.18; 95% CI: 1.25, 8.08).[3] A systematic review by Haddad et al. (2016) included four studies conducted in several African and Middle Eastern countries (three cross-sectional and one case-control) that reported waterpipe smoking increased the risk of COPD in adults.[21] This review further reported on one cross-sectional study among adults over age 40 which found secondhand exposure to waterpipe smoke was significantly associated with COPD. Lastly, this same review reported on another cross-sectional study which found secondhand waterpipe smoke was associated with symptoms of airway obstruction among a sample of Syrian females aged 6 and older.[21] Another review found mixed results with two studies finding an association between waterpipe smoking and COPD and two studies finding no association.[24] However, the authors of this review stated that the two studies that found no association were methodologically flawed.[24]

CHRONIC BRONCHITIS

All four reviews that assessed waterpipe smoking and chronic bronchitis, described as chronic cough with sputum production, found a significant association.[3,17,18,24] For example, the strong quality meta-

analysis by Waziry et al. (2017) found, based on two included primary studies (one case-control and one cross-sectional), waterpipe smokers had significantly greater odds of chronic bronchitis compared to non-smokers (OR: 2.37; 95% CI: 1.49, 3.77).[3] A moderate quality review by El Zaatari et al. (2015) reports on six included cross-sectional studies conducted in multiple Asian, Middle Eastern and North African countries that all found an association between waterpipe smoking and chronic bronchitis.[24] One of these studies also found symptoms of chronic bronchitis to be more severe among waterpipe smokers compared to non-smokers.[24] Finally, based on a single study of waterpipe use in the Middle East and North Africa, Pratiti et al. (2019) report that daily waterpipe smoking, independent of cigarette smoking, is associated with chronic bronchitis (OR: 1.43), productive cough (OR: 1.49), and breathlessness (OR: 1.33); however, given no CIs nor p values are reported, these results should be interpreted with caution.[17]

COUGHING/WHEEZING

Six reviews reported a positive association between waterpipe exposure and coughing/wheezing, most reporting results from countries in Africa and the Middle East, and some do not report the jurisdictions of included studies.[3,17,18,21,23,30] More specifically, these reviews explored two exposures: waterpipe smoking and passive waterpipe tobacco smoke/secondhand smoke. One moderate quality review found that chronic cough is significantly associated with waterpipe smoking.[21] A strong quality meta-analysis found passive waterpipe tobacco smoking to be significantly associated with respiratory illness (i.e., nasal congestion and wheezing) (OR: 1.97; 95% CI: 1.28, 3.04).[3] Other reviews support this finding by reporting a higher prevalence of wheezing/coughing among children exposed to secondhand smoke from waterpipe smoking in the home compared to those who had no exposure.[17,23]

OTHER RESPIRATORY EFFECTS

Other respiratory effects reported in the literature are regarding pulmonary function, nasal mucociliary clearance, asthma and acute eosinophilic pneumonia. Two reviews concluded that waterpipe smoking causes decreased pulmonary function, specifically forced expiratory flow.[21,24] One strong quality review reported impaired nasal mucociliary clearance in waterpipe smokers compared to non-smokers among participants ages 18 to 41.[29] A moderate quality review reported that the association between waterpipe smoking and asthma remains inconclusive due to uncertainty around concurrent effects of cigarette smoking.[24] One review described cases of acute eosinophilic pneumonia, a respiratory disease known to be linked to cigarette smoking, in individuals exposed to non-cigarette smoking including waterpipe, the majority of whom were under age 30.[33] Authors found these clinical presentations to be similar to cases of acute eosinophilic pneumonia in cigarette smokers with cases commonly experiencing shortness of breath, cough, fever, elevated white blood cell counts and leaukocytosis.[33]

Perinatal and Childhood Outcomes

Six reviews examined the association between waterpipe smoking during pregnancy and perinatal outcomes.[3,17,18,24,27,28] Low birth rate was the most commonly reported perinatal outcome, with all six reviews reporting a positive association.[3,17,18,24,27,28] One strong quality meta-analysis found maternal waterpipe tobacco smoking significantly increased the likelihood of low birth weight (OR: 2.39; 95% CI: 1.32, 4.32).[3] One review reporting a positive association between waterpipe smoking during pregnancy and low birth weight notes the included studies were methodologically limited.[24]

Other outcomes found to be associated with waterpipe smoking during pregnancy are newborn and childhood respiratory problems,[3,17,18] sudden infant death syndrome,[28] and longer term issues with memory, learning, emotional and behavioural development due to disrupted fetal development.[28] As

noted above, evidence also indicates children exposed to secondhand waterpipe smoke are at increased risk of adverse respiratory effects such as coughing and wheezing.[17,23]

Infectious diseases

Five reviews addressed the effects of waterpipe smoking on infectious diseases.[3,24,28,30,31] Three reviews[3,24,28] examined the association between waterpipe smoking and hepatitis C and reported conflicting results, with two reviews concluding no association[3,24] and one weak quality review reporting an association.[28] Two weak quality reviews reported on the association between waterpipe smoking and COVID-19.[30,31] Haddad et al. (2021) concluded that waterpipe smoking may increase transmission of COVID-19 via inadequate cleaning of waterpipes between users and smoking in groups. However, it is important to note that this result is based on known facts about COVID-19 and typical use of waterpipes and not on real world studies.[30] Gupta et al. (2021) describe a single study of COVID-19 patients in Iran which found the majority of patients who were cigarette smokers reported their COVID-19 symptoms as severe, 40% of patients who were waterpipe smokers reported their symptoms as severe and 22% of non-smokers reported their symptoms as severe.[31] This finding is limited by lack of reporting on how exposures and outcomes were measured and how analysis was conducted. Finally, one weak quality study reported that waterpipe smoking can transmit tuberculosis.[28] Of note, there is evidence to indicate microbial contamination, including antibiotic resistant bacteria, of waterpipe devices can occur not only on mouthpieces, but also on the inner surface of the waterpipe hose, the water chamber and the water itself, which are typically cleaned less often and are more challenging to clean effectively.[14]

Oral Health

Periodontal disease is measured through vertical bone height loss, periodontal pocket depth, and plaque and gingivitis indexes.[3,17] The identified literature reports mixed results on the association between waterpipe smoking and periodontal disease.[3,17,18,20,24,25,35] One systematic review reported on four cross-sectional studies assessing the impact of waterpipe tobacco smoking on various periodontal disease measures among the same study population.[3] All studies found positive associations with ORs ranging from 3.00 to 5.00, however statistical significance was not reported and review authors ultimately concluded there to be no association between waterpipe smoking and periodontal disease.[3] On the other hand, five reviews concluded that there is an association between waterpipe smoking and periodontal disease.[17,18,24,25,35] However, the authors of one of these reviews noted the lack of adjustment for confounders in the included studies.[24] One review found mixed results investigating the impact of waterpipe smoking on gingivitis and plaque indexes.[20] Evidence on another measure of oral health, oral lesions, was found to be inconclusive.[20,24] Finally, the incidence of dry socket after tooth extraction was consistently found to be increased in waterpipe smokers.[3,17,20,25]

Other Health Outcomes

Several less common health outcomes were reported across included evidence, however due to the small body of evidence these topics would benefit from further research, and results should be interpreted with caution. There is some evidence to suggest an association between waterpipe smoking and mental health diagnoses,[3] lower quality of life,[3,13] nicotine dependence,[12,17,18,28] gastro-oesophageal reflux disease,[3,17] and all-cause mortality.[3,17] Reviews examining the association between waterpipe smoking and obesity are inconsistent, with two reviews[17,19] reporting an association and one meta-analysis[15] reporting no significant association.

Biomarkers

Available literature suggests a positive association between waterpipe smoking and a range of biomarkers including reduced cell proliferation;[17,21,22,25] impaired cell repair;[14,17,22,25] inflammation;[22,25] increased triglyceride, fibrinogen and fasting blood glucose levels;[15] higher coronary artery calcium scores;[15] and oxidative stress.[15,17] Moreover, waterpipe smokers were found to have higher levels of heavy metals (e.g., chromium, arsenic, nickel) in their bloodstream.[21,25,28] Exhaled CO and carboxyhemoglobin levels were not only found to be significantly higher in waterpipe smokers compared to non-smokers, but also compared to cigarette smokers.[7,18,22,24,28,32] These biomarkers play a role in developing chronic diseases.[17]

Air Quality

Air quality is a measure of potentially harmful toxins and chemicals in the air such as PM, PAHs, CO, and heavy metals.[23] Four reviews examined the presence of PM in waterpipe smoke or waterpipe lounges, with all four reviews reporting PM levels that exceed established safe limits.[5,17,18,23] For example, Pratiti et al. (2019) reported results from a study examining tobacco-based waterpipe smoke and PM smaller than 2.5 µm in diameter ($PM_{2.5}$) in the indoor air of public waterpipe lounges. This study found high $PM_{2.5}$ levels in ambient air of waterpipe lounges (515 µg/m3), which is well above the Environmental Protection Agency safe limit of 35 µg/m3.[17] Specific to the Canadian context where tobacco-based waterpipe smoking is banned, one study examining air quality in waterpipe lounges across Canada (where presumably only herbal products are smoked) found hazardous levels of PM.[5] Two reviews also reported higher levels of PM in waterpipe venues compared to venues where cigarettes are smoked.[5,23] For example, Kumar et al. (2015) reported the findings of one study where PM levels in waterpipe cafes had a mean of 374 µg/m3 and venues that only allowed cigarette smoking had a mean of 119 µg/m3.[23]

PAHs are carcinogenic[5,14,23] and are known to increase the risk of cancer and cardiovascular disease.[18] Five weak quality reviews reported that waterpipe smoke contains PAHs.[5,14,18,22,23] Two reviews further reported that waterpipe smoke contained higher levels of PAHs compared to smoking one cigarette.[5,23] One review also reported findings from a study that found similar or higher levels of PAHs in herbal waterpipe smoke compared to nicotine-based waterpipe smoke.[23]

Six weak[5,14,18,22,23] to moderate quality[17] reviews reported that waterpipe smoke contains tar, nicotine, and CO. For example, Shihadeh et al. (2015) reported that waterpipe smoke contains 57.2 to 367 mg of CO per smoking session, whereas smoking one cigarette yields 14 to 23 mg CO.[22] Pratiti et al (2019) reported on a study of waterpipe cafes in the United States which found ambient CO concentration to be 20.5 parts per million, which is above established air quality standards.[17] Pratiti et al (2019) further reported that some waterpipe smoking can lead to CO poisoning that requires medical attention.[17] Maziak et al. (2019) reported that levels of harmful toxins emitted in waterpipe smoke are similar to those found in cigarette smoke, except tar and CO, which were found to exist in higher levels in waterpipe smoke.[18] The amount of CO found in waterpipe smoke is largely due to the amount of charcoal used and can be lessened if electric heating is used.[22] However, the use of electric heating is also harmful as it has been found to increase the amount of volatile aldehydes (associated with respiratory disease), indicating no “safe” heating method for waterpipe smoking.[5]

Two studies examining the levels of heavy metals in waterpipe smoke reported equal or higher concentrations than levels found in cigarette smoke.[5,22]

Waterpipe Smoking versus Cigarette Smoking

The available literature suggests that both waterpipe and cigarette smoking are harmful, with many similar health effects. Compared to cigarette smokers, waterpipe smokers have been found to have higher levels of triglycerides,[15] fibrinogen,[15] and long-term levels of carboxyhemoglobin.[24,28,32] Waterpipe smokers are exposed to similar levels of nicotine as cigarette smokers (when using a tobacco-based product)[7,22,32] and significantly lower levels of tobacco-specific nitrosamines.[7,22] Al Ali et al. (2020) reported that after removing statistical heterogeneity, waterpipe smokers have a higher mean HR by 3.21 (95% CI: 2.31, 4.11), SBP by 2.82 (95% CI: 1.15, 4.49) and DBP by 2.38 (95% CI: 0.98, 3.79) compared to cigarette smokers.[15] Al Ali et al. (2020) found no significant difference in cardiovascular disease incidence between waterpipe and cigarette smokers but did find that among CAD patients, waterpipe smoking was associated with higher severity of CAD compared to cigarette smoking.[15] Five studies examining the contents of waterpipe and cigarette smoke found that waterpipe smoke contains increased levels of PM,[5,23] CO,[5,17,18,22,23] PAHs,[23] volatile aldehydes,[23] tar,[17,18,22] and toxic metals[22] compared to cigarette smoke.

Discussion and Conclusions

Overall, available evidence suggests that waterpipe smoking and exposure to waterpipe smoke are associated with multiple harmful health outcomes. Evidence consistently supported positive associations between waterpipe smoke exposure and lung cancer, [1,3,4,7,16-18,21,24] adverse cardiovascular effects,[3,11,15,17-19,21,24] adverse respiratory effects,[3,17,18,21,23,24,29,30] low birth weight,[3,17,18,24,27,28], and poor air quality.[5,17,18,23] More research is needed to determine the true effects of waterpipe smoke on other types of cancer [1-4,7,16,20,21,24,25], oral health[3,17,18,20,24,25,35] and obesity.[15,17,19]

The literature indicates similar levels of toxins in both tobacco-based and tobacco-free waterpipe smoke, with the exception of nicotine.[24] Therefore, it is plausible that the mechanisms through which many of these health outcomes are facilitated is through carcinogens and other toxic particles from the burning of charcoal and inhalation of smoke, regardless of product type.[22] The acute increase in HR was the only health outcome where a similar effect was not observed across both tobacco and non-tobacco waterpipe smokers, thus suggesting nicotine was the mediator.[24]

Special consideration was given to four topic areas: disposable mouth pieces, room configuration, ventilation, and cultural considerations. Five studies mentioned that the effectiveness of disposable mouth pieces is undetermined and that transmission of infectious diseases may still occur due to contamination of the hose or water bowl.[5,14,28,30,31] Although no reviews mentioned ventilation directly, one review did report that indoor venues had hazardous levels of $PM_{2.5}$ with a mean of 1419.4 µg/m3, while outdoor venues had lower but still unsafe levels of $PM_{2.5}$ with a mean of 80.5 µg/m3.[23] This suggests that even in areas with good ventilation (e.g., outdoor patios), there is still a risk of unsafe levels of $PM_{2.5}$. While several included reviews mention the prevalence of waterpipe smoking to be higher in certain locations, such as eastern Mediterranean and European regions,[18] there was insufficient evidence produced by our search to meaningfully speak to the intersection of cultural considerations and policies addressing the health impacts of waterpipe smoking in Ontario. Although out of scope for this search, we are aware others have explored these relationships using different methods.[36] Finally, three reviews reported on the risk to both smokers and non-smokers due to the toxins found in secondhand and thirdhand waterpipe smoke (i.e., residual components of smoke which remain on surfaces and in dust).[1,4,23] Kumar et al. (2015) further showed that non-smoking sections of waterpipe cafes had similar levels of $PM_{2.5}$ as restaurants where cigarettes are smoked.[23] This suggests

that a dedicated area for smoking and non-smoking within the same establishment does not eliminate the risk to non-smokers.

Limitations

There are several limitations to consider when interpreting the results of this evidence brief. There was variation in the methods used to measure waterpipe exposure and health outcomes among studies.[1-3,7,13-15,24,25] Many of the studies did not use a standardized measurement or reporting methods for waterpipe exposure that takes into consideration puffing parameters, duration of smoking session, nor quantity of tobacco used.[3,24,25] This could result in a measurement bias.[1] Furthermore, many studies did not specify the type of tobacco used (e.g., traditional versus flavoured tobacco or processed versus unprocessed tobacco).[7,24]

Related, many of the included studies did not control for confounding variables such as other forms of tobacco smoking.[4,7,11,13,15,21,24,25,30] Therefore, it is difficult to assess the true harms of waterpipe-only smoking.[21] Many included reviews did not describe characteristics—such as age, gender or baseline health status—of the samples assessed in primary studies. Next, many of the included studies were conducted in Middle Eastern regions or other developing countries,[1,2,5,13,15,19,25] or the study jurisdiction were not reported. This limits the generalizability of the results to developed countries due to potential differences in contextual, cultural and policy environments. Many reviews also noted limited data available. [1,4,5,11-14,27,29,31,35]

Finally, the overall quality of the included reviews varied greatly with nine reviews rated as strong,[1-4,7,19,27,29,35] nine rated as moderate,[10,11,15,17,20,24,25,33,34] and 14 rated as weak.[5,12-14,16,18,21-23,26,28,30-32] Many of the reviews that scored lower on the Health Evidence Quality Assessment Tool did not assess the quality of their included studies, did not have a comprehensive search strategy, and did not provide sufficient information on the methods of the included studies.

Implications for Practice

There is evidence of a rise in popularity of waterpipe smoking internationally, as well as establishments like hookah lounges and bars and restaurants which permit waterpipe smoking.[4] Although prevalence and changes in waterpipe use specifically in Ontario are less clear, there is evidence from the United States indicating small increases of waterpipe use among youth over time.[18] In Ontario, the *Smoke-Free Ontario Act* prohibits the use of tobacco in waterpipes on restaurant and bar patios.[8] Under this act, however, the use of non-tobacco products in waterpipes is still permitted.[8] This distinction makes it difficult for inspectors to enforce the *Smoke Free Ontario Act* and it sends confusing messages to users regarding the health effects of using waterpipes.

Despite the limitations mentioned previously, this synthesis of review-level literature since 2015 shows compelling evidence that waterpipe use, regardless of product type, has harmful health effects for those smoking waterpipe, and those exposed to the secondhand smoke. Given this finding and the continued use of waterpipes in hookah lounges, restaurants and bars, it is important that legislation surrounding waterpipe smoking (regardless of product type) be implemented and enforced. Additionally, clearer communication regarding these adverse health effects should be directed towards the public to increase awareness and facilitate more informed decision-making related to waterpipe smoking.

Additional Resources

- Smoke-free Series: Post-Consumer Waste

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Specifications and Limitations of Evidence Brief

The purpose of this Evidence Brief is to investigate a research question in a timely manner to help inform decision making. The Evidence Brief presents key findings, based on a systematic search of the best available evidence near the time of publication, as well as systematic screening and extraction of the data from that evidence. It does not report the same level of detail as a full systematic review. Every attempt has been made to incorporate the highest level of evidence on the topic. There may be relevant individual studies that are not included; however, it is important to consider at the time of use of this brief whether individual studies would alter the conclusions drawn from the document.

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