RESEARCH ARTICLE

Assessing the Effect of Waterpipe Smoking on Cancer Outcome - a Systematic Review of Current Evidence

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Abstract

Background: Waterpipe smoking (WPS) is widely believed to be a safe and hazard-free tobacco habit. However, a number of studies have indicated that exposure to several toxicants and carcinogens through WPS is strongly related to serious health hazards. The current paper presents a narrative review on the effects of WPS on cancer outcome. **Methods:** The addressed focused question was "Is there an association between waterpipe smoking and cancer outcome?" PubMed, Medline, EMBASE, ISI Web of Science and the Cochrane databases were searched until June 2015 using the key words "Waterpipe", "Hookah", "Narghileh", "Shisha", "Hubbly Bubbly" "cancer" in various combinations. Letters to the Editor, review articles, case-reports and unpublished articles were excluded. **Results:** A total of 16 studies were included: six on lung cancer, three on oesophageal cancer, two on gastric cancer, two on bladder cancer, and one each on nasopharyngeal, pancreatic and prostate cancers. Our search did not yield any study that evaluated the risk of oral cancer in WPS users. The available evidence showed a significant association of WPS with lung cancer (UOR 6.0, 95% CI 1.78–20.26); however, no association was observed with bladder, nasopharyngeal, pancreatic and prostate cancers. Gastric (OR 3.4, 95% CI 1.7-7.1) and oesophageal cancers (OR 1.85, 95% CI 1.41-2.44) were observed to have weak associations with WPS. **Conclusion:** Regardless of the limitations, there is sufficient evidence to suggest associations of WPS with cancer, particularly in the lung. Future well-designed studies are required to identify and quantify with confidence all the health effects of this form of smoking.

Keywords: Waterpipe smoking- shisha-tobacco- cancer- systematic review

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Introduction

Waterpipe smoking (WPS) is estimated to have a global prevalence of 100 million, most of which is among adolescents (Gatrad et al., 2007; Akl et al., 2011). A number of epidemiological and questionnaire-based studies have identified several factors responsible for this ever-increasing global use of waterpipe; (a) presentation of water pipe tobacco in different pleasant and palatable flavors and aromas (Maziak et al., 2014; Maziak et al., 2015; Awan et al., 2016); (b) misconception about its safety of use compare to cigarette smoking (Maziak et al., 2014); (c) social approval and its common use among peer gatherings, café and restaurants (Maziak et al., 2014; Maziak et al., 2015; Awan et al., 2016); (d) advertisement on social, print and electronic media (Maziak et al., 2014; Maziak et al., 2015); (e) nominal cost (Maziak et al., 2014); (f) absence of waterpipe-specific strategies and legislations (Maziak et al., 2014; Maziak et al., 2015); and (g) people migrating from Middle-eastern region to Western regions (Maziak et al., 2015). Several studies have now disproved misconceptions about the safety and reduced harm of WPS by highlighting the presence of various dangerous toxins and carcinogens in its smoke and lack of their 'filtration' through the water (Shihadeh and Saleh, 2005; Daher et al., 2010).

Contrary to the misconception about the safety of waterpipe, a number of studies have reported its unfavorable effects on health (American Lung Association, 2007; Warnakulasuriya, 2011).8,9 WPS has been identified as a risk factor for several tobacco-associated diseases, including different malignancies, cardiovascular diseases and pregnancy-related outcomes. Furthermore, the waterpipe smokers are exposed to various dangerous metals/chemicals and communicable diseases through its non-tobacco components and shared/repetitive use respectively (Habib et al., 2001; Shihadeh, 2003; Shihadeh and Saleh, 2005; Steentoft et al., 2006).

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There have been a few reviews that have outlined the health effects of WPS (Akl et al., 2010; Maziak, 2013; El-Zaatari et al., 2015), however, to the best of our knowledge there is no systematic review that has highlighted the health-related outcomes of WPS specific to cancer. Thus, the purpose of this paper is to present a systematic review of the current evidence on the association of WPS with cancer outcome.

Material and methods

Focus question

We formulated a key question "Is there an association between WPS and cancer outcome?"

Eligibility criteria

All original clinical studies including cohort, case-control and cross-sectional studies were included to assess the association of WPS with cancer. Case reports, experimental studies, review articles, letters to the editor, unpublished data and articles not published in English were excluded. Studies that reported physiological outcomes, evaluated WPS for non-tobacco purposes, and did not distinguish WPS from other forms of smoking were also excluded.

Search strategy

Detailed automated literature searches of PubMed, Medline, EMBASE, ISI Web of Science and the Cochrane databases from January 1980 up to and including June 2015 were conducted. Various combinations of the following keywords and Boolean operators were used: "Waterpipe", "Hookah", "Narghileh", "Shisha", "cancer". Review articles were also searched for additional articles missed in the automated searches.

Data collection and abstraction

Two reviewers (KHA, SP) initially screened titles and abstracts of studies based on above-mentioned protocol. Full texts of studies found relevant were retrieved and independently reviewed using a standardized and pilot-tested form. The studies were only included in the review after agreement of both the authors. The agreement between the two reviewers was calculated using the kappa statistics (Cohen's kappa score = 1).

For the ease of analysis, all the selected studies were systematically arranged in tables. The abstracted data included participants' characteristics (age, gender, location), study type and methodology, any biases such as lack of control for cigarette smoking or other cofounders and association with cancer.

Results

Study characteristics

A total of 16 studies that matched the eligibility criteria were included in this review (Figure 1); six studies on lung cancer (Lubin et al., 1990; Lubin et al., 1992; Gupta et al., 2001; Hazelton et al., 2001; Koul et al., 2011; Aoun et al., 2013), three on oesophageal cancer (Nasrollahzadeh et al., 2008; Malik et al., 2010; Dar et al., 2012), two on

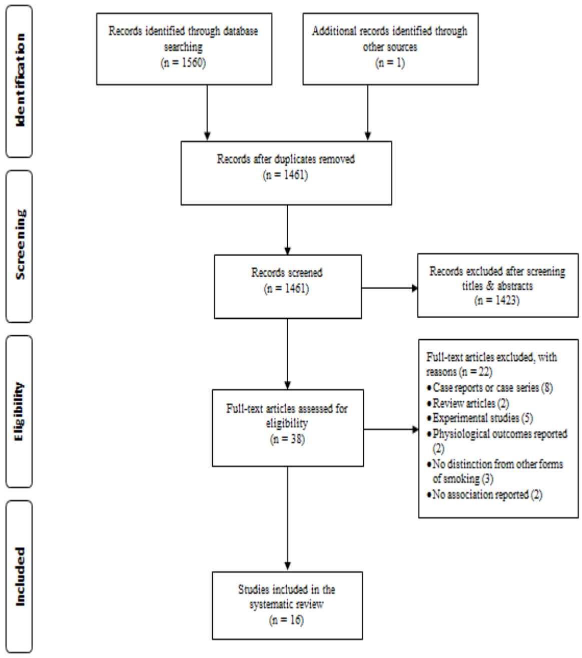

Figure 1. PRISMA Flowchart of Identification and Selection of Studies for Inclusion in the Systematic Review

gastric cancer (Gunaid et al., 1995; Sadjadi et al., 2014), two on bladder cancer (Bedwani et al., 1997; Zheng et al., 2012) and one each on nasopharyngeal (Feng et al., 2009), pancreatic (Lo et al., 2007) and prostate cancers (Hosseini et al., 2010). Thirteen studies were case-control studies (Lubin et al., 1990; Lubin et al., 1992; Bedwani et al., 1997; Gupta et al., 2001; Lo et al., 2007; Nasrollahzadeh et al., 2008; Feng et al., 2009; Hosseini et al., 2010; Malik et al., 2010; Koul et al., 2011; Dar et al., 2012; Zheng et al., 2012; Aoun et al., 2013), two were cohort studies (Hazelton et al., 2001; Sadjadi et al., 2014), and only one had a cross-sectional study design (Gunaid et al., 1995). Table 1 shows the summary of the included studies.

Association with lung cancer

The association of WPS with lung cancer was reported in five case-control studies (Lubin et al., 1990; Lubin et al., 1992; Gupta et al., 2001; Koul et al., 2011; Aoun et al., 2013), and one retrospective cohort study (Hazelton et al., 2001). Three of the studies were conducted in China (Lubin et al., 1990; Lubin et al., 1992; Hazelton et al., 2001), two in Northern India (Gupta et al., 2001; Koul et al., 2011) and one was conducted in Lebanon (Aoun et al., 2013).

WP smokers were observed to have a six-fold greater risk of developing lung cancer in studies among the Lebanese and Indian population (Koul et al., 2011; Aoun et al., 2013), however, the association was not adjusted for cofounding factors or became insignificant after adjustment. Another study carried out among Indian male WP smokers (aged > 45 years) showed similar high odds (OR=4.44) after adjusting age and education (Gupta et al., 2001). Studies from China also demonstrated an association of WPS with lung cancer and a pooled OR of 2.12 (Hosseini et al., 2010). However, the Chinese studies did not adjust the cofounding factors such as cigarette

Table 1. Characteristics of Included Studies assessing the Effect of Waterpipe Tobacco Smoking on Cancer Outcomes

Author et al (year)	Cancer type	Study design	Methodological features	OR (95% CI)	Comments
Auon et al -2013	Lung	- Study type: Case-control - Setting and period: Tertiary healthcare center, Lebanon; March-June 2012 - Cases: 50 cases of lung cancer patients; average age 59.58 years (±6.03) - Controls: 100 patients with non medical or other medical problems (urinary, kidney, orthopedic, endocrinologic & gynecologic problems); average age 59.82 years (±6.31)	- Measurement tool: Self-developed validated questionnaire - Controlled for cigarette smoking - Adjusted for other cofounding factor	- 6.0 (1.78–20.26)	- Non-significant OR after adjustment for confounders
Koul et al-2011	Lung	- Study type: Case-control - Setting & period: Sher-i-Kashmir Institute of Medical Sciences, Srinagar, Kashmir (India) - Cases: 251 cases of lung cancer; 209 males & 42 females - Controls: 500 age-matched controls; 328 male & 72 female - Mean age: Males 58.4 yrs; females 56.5 yrs - Ever-smokers: 77% cases; 44.6% controls - Exclusive WP smokers: 48% cases; 20% controls	- Measurement tool: Interview; self-developed validated questionnaire - Not controlled for cigarette smoking - Not adjusted for other cofounders	- 5.83 (3.95-8.60)	- Significant association of hookah smoking with lung cancer
Gupta et al-2001	Lung	- Study type: Case-control - Setting & period: Chandigarh, North India; January 1995 - June 1997 - Cases: 265 histologically confirmed patients of lung cancer; 235 males, 30 females - Controls: 525 age/sex-matched controls; 435 males, 90 females - Ever smokers: 83% cases; 53% controls	- Measurement tool: Self-developed, no standardization - Controlled for cigarette smoking and adjusted for other cofounding factors	- Adjusted = 4.44 (1.2-16.44)	- OR for Male heavy smokers older than 45 years - Numbers for women were too small to derive stable risk estimates
Luban et al-1990	Lung	- Study type: Case-control - Setting & period: Gejiu city, Yunnan Province, China; conducted in 1985 - Cases: 74 cases of lung cancer; all males; alive at the time of the study reported to Labor Protection Institute of the YTC during 1981–84 - Controls: 74 controls chosen from the list of all living past or present workers of the YTC; one control per case - Mean age: 62 years (range 35–80)	- Measurement tool: Self-developed questionnaire, no standardization - Not controlled for cigarette smoking - Not adjusted for other cofounders	- OR compared with no tobacco smoking: - 3.6 (waterpipe only smoking) - 1.2 (cigarette only smoking)-3.5 (mixed smoking)	- Increased risk with cumulative exposure
Hosseini et al (2010)	Prostate	- Study type: Case-control - Setting & period: Mazandaran cancer registry, Mazandaran Province in northern Iran; 2005-2008 - Cases: 137 male histologically confirmed prostate cancers - Controls: 137 male neighborhood and age group matched controls - Age groups: ≤ 70 yrears = 111; 70 – 80 years = 130; > 80 years = 33	- Measurement tool: Interviews; self-developed questionnaire; no standardization reported - Controlled for cigarette smoking - Adjusted for other cofounding factors	- OR = 7.0 (0.9-56.9)	- Number of WP smokers was too small

Table 1. Continued

Author et al (year)	Cancer type	Study design	Methodological features	OR (95% CI)	Comments
Luban et al-1992	Lung	- Study type: Case-control - Setting & period: Gejiu city, Yunnan Province, China -Cases: 427 lung cancer patients; all males; mean age = 63 years (range 35–75) - Controls: 1011 controls; all males; two controls per case; mean age = 62 years (range 35–75)	- Measurement tool: Self-developed questionnaire, no standardization - Controlled for cigarette smoking - Adjusted for other cofounding factors	- OR compared with no smoking: 1.8 (95% CI 0.8-4.2) (waterpipe only smoking); 2.6 (95% CI 1.1–6.2) (cigarette only)	- Did not control for Chinese long-stem pipe smoking
Hazelton et al-2001	Lung	- Study type: Retrospective cohort - Setting & period: Gejiu city, Yunnan Province, China; 12 years follow-up (1976–88) - Sample: 12011 males working for the YTC	- Measurement tool: Not reported, calculated as cumulative exposure - Controlled for cigarette smoking - Adjusted for other cofounding factors	- RR compared with no smoking = 4.39 (95% CI 3.82–5.04) (water pipe smoking)	- Smoking a bamboo water pipe or a Chinese long stem pipe appears to confer less risk than cigarette use, given equivalent tobacco consumption.
Dar et al-2012	Oesophageal	- Study type: Case-control - Setting & period: Regional Cancer Centre & Department of Radiation Oncology of Sher-i-Kashmir Institute of Medical Sciences, Srinagar, Kashmir, India; September 2008 to January 2012 - Cases: 702 cases of oesophageal squamous cell carcinoma; 392 males & 310 females; mean age = 61.6 years - Controls: 1663 age/sex-matched controls; 919 males & 744 females; mean age = 59.8 years	- Measurement tool: Self developed questionnaire - Controlled for cigarette smoking - Adjusted for other cofounding factors	- Adjusted = 1.85 (1.41-2.44)	- Increased risk with increased frequency, duration and cumulative WPS
Malik et al-2010	Oesophageal	- Study type: Case-control -Setting & period: Kashmir, India - Cases: 135 oesophageal cancer patients - Controls: 195 healthy controls	- Not controlled for cigarette smoking - Adjusted for other cofounding factors	- Adjusted = 21.4 (11.6-39.5)	
Nasrollahzadeh et al (2008)	Oesophageal	- Study type: Case-control - Setting & period: Atrak Clinic in Gonbad City, Eastern Golestan Province of Iran; December 2003 - June 2007 - Cases: 300 cases of oesophageal squamous cell carcinoma; 150 males & 150 females; mean age = 64.5 (10.1) years - Controls: 571 controls (271 had two matched controls and 29 had one); mean age = 64.3 (10.4) years	- Measurement tool: Self-developed questionnaire, tested for reliability & validity - Controlled for cigarette smoking - Adjusted for other cofounding factors	- Adjusted = 1.69 (95% CI 0.76–3.77)	- All forms of tobacco use (cigarettes, hookah, and nass) were associated with higher oesophageal squamous cell carcinoma risk
Sadjadi et al-2014	Gastric	- Study type: Prospective cohort - Setting & period: Ardabil Province, Northwest Iran; 10 years follow-up - Sample: 928 randomly selected, healthy, Helicobacter pylori-infected subjects; - Gender: 49.1% males - Mean age = 53.1 (9.9) years	- Measurement tool: Self-developed, validated questionnaires - Controlled for cigarette smoking - Adjusted for other cofounding factors	- Adjusted = 3.4 (1.7-7.1)	- Hookah use is a risk factor for gastric cancer as well as for precancerous lesions.

Table 1. Continued

Author et al (year)	Cancer type	Study design	Methodological features	OR (95% CI)	Comments
Gunaid et al -1995	Gastric	- Study type: Cross-sectional - Setting & period: Al-Thawra Hospital in Sana'a, Republic of Yemen; January-December 1991 - Sample: 3064 patients who underwent upper gastrointestinal endoscopy	- Measurement tool: Unclear - Unclear whether controlled for cigarette smoking - Not adjusted for other cofounding factors	- Not calculated ($\chi2$=2.646, P<0.05)	- Number of gastric cancer cases was too small to draw significant conclusions. Most WP smokers were also Khat chewers, and an individual effect could not be discerned
Zheng et al -2012	Bladder	- Study type: Case-control - Setting & period: Three collaborating cancer centers in Egypt (National Cancer Institute in Cairo, the Minia Oncology Center in Minia, the South Egypt Cancer Institute in Assiut); July 2006-July 2010 - Cases: 1,886 newly diagnosed and histologically confirmed cases; 1535 males & 351 females - Controls: 2,716 age-, gender-, and residence-matched, population-based controls; 2089 males & 627 females	- Measurement tool: Self-developed structured questionnaire - Controlled for cigarette smoking - Adjusted for other cofounding factors	- Adjusted - 1.3 (1.0 - 1.9) for Urothelial cancer cases 1.0 (0.7 - 1.5) for Squamous cell carcinoma cases	- Among WP smokers only, no significant association between WPS & bladder cancer observed -Men who smoked both WP and cigarettes, the risk of bladder cancer was significantly higher
Bedwani et al -1997	Bladder	- Study type: Case-control - Setting & period: Greater Alexandria, Egypt; January 1994 - July 1996 - Cases: 151 males with incident, histologically confirmed invasive cancer of the bladder; median age 61 years (range 31–74) - Controls: 157 males admitted to hospital for acute, non-neoplastic, non-urinary tract, non-smoking-related conditions; median age 50 years (range 32–74)	- Measurement tool: Self-developed structured questionnaire; standardization not reported; participants categorized as ever smokers & never smokers - Controlled for cigarette smoking - Adjusted for other cofounding factors	- Adjusted = 0.8 (0.2–4.0)	- No increased bladder cancer risk with habits other than cigarette smoking
Feng et al 2009	Nasopharyngeal	- Study type: Case-control - Setting & period: Five hospitals in Algeria, Morocco, and Tunisia; January 2002-March 2005 - Cases: 636 incident cases of nasopharyngeal cancer - Controls: 615 controls [patients hospitalized for non-cancer diseases (61%) and friends and family of non-cancer patients (39%)]	- Measurement tool: Interviews; self-developed questionnaire; no standardization reported - Not controlled for cigarette smoking - Adjusted for other cofounding factors	- Adjusted = 0.49 (0.20-1.43)	- Shisha showed no association with nasopharyngeal cancer - Number of WP smokers was too small
Lo et al 2007	Pancreatic	- Study type: Case-control - Setting & period: 2 major hospitals in Egypt [(Gastrointestinal Surgery Center (GSC) of Mansoura University and National Cancer Institute of Cairo University (NCI-Cairo)]; January 2001-March 2004 - Cases: 194 newly diagnosed pancreatic cancer cases; age ranged from 15 to 90 years (mean ± SD, 56.4 ± 13.0 years) - Controls: 194 subjects with acute illnesses admitted to the Departments of Ear/Nose/Throat & Ophthalmology at either GSC or NCI-Cairo; age ranged from 14 to 84 years (mean ± SD, 54.4 ± 14.9 years)	- Measurement: Interviews; self-developed validated questionnaire - Not controlled for cigarette smoking - Adjusted for other cofounding factors	- Adjusted = 1.6 (0.9-2.8)	- WPS was combined with other non-cigarette smoking types like pipe and cigar

Table 2. Comparison of Chemicals Found in Waterpipe Smoke versus Cigarette Smoke

Chemical	Yield from cigarette smoke (1gm tobacco)	Yield from waterpipe smoke (1gm tobacco)	Multiple of average cigarette smoke value
Tar (mg)	Range =1 - 27 Average = 11.2	802.0	100-folds
Nicotine (mg)	Range = 0 – 1.2 Average = 0.77	2.96	4-folds
Carbon monoxide (mg)	Range = 1 – 22 Average = 12.6	14.3	11-folds
PAH			
Phenanthrene, µg (co-carcinogen)	0.2 – 0.4	0.748	2.5-folds
Fluoranthene, µg (co-carcinogen)	0.009–0.099	0.221	4-folds
Chrysene, µg (co-carcinogen)	0.004–0.041	0.112	5-folds

smoking or Chinese long-term pipe smoking.

Association with Oesophageal cancer

Association of WPS with oesophageal cancer was reported in three case-control studies (Nasrollahzadeh et al., 2008; Malik et al., 2010; Dar et al., 2012). A study conducted in Northern India showed a two-fold greater risk (OR=1.85, 95% CI 1.41-2.44) of developing oesophageal cancer among WP smokers, with risk further increasing with increased frequency, duration and cumulative WPS (Dar et al., 2012). Another Indian study reported a very strong association of WPS with oesophageal cancer (OR=21.4, 95% CI 11.6-39.5); however, the study did not report the data on the concurrent use of cigarettes or other tobacco-related products (Malik et al., 2010). In a study that adjusted for cigarettes and other cofounding factors (Nasrollahzadeh et al., 2008), WPS showed insignificant association with oesophageal cancer (OR=1.69, 95% CI 0.76–3.77).

Association with gastric cancer

Two studies reported association of WPS with gastric cancer (Gunaid et al., 1995; Sadjadi et al., 2014). A three-fold greater risk (OR=3.4, 95% CI 1.7-7.1) of developing gastric cancer was observed among a large cohort of Iranian WP smokers, after adjusting for the cofounding factors (Sadjadi et al., 2014). Another study showed a significant relationship between WPS and gastric cancer; however, the number of WP smokers was insufficient to measure the effects independent of the cofounding factors (Gunaid et al., 1995).

Association with bladder cancer

Contrary to the recognized association of cigarette smoking with bladder cancer, an insignificant association was observed between WPS and bladder cancer (Bedwani et al., 1997; Zheng et al., 2012). Both the case-control studies were carried out in Egypt and reported the results adjusting the cigarette smoking and other cofounding factors.

Association with nasopharyngeal, pancreatic and prostate cancers

Only one case-control study (Feng et al., 2009) reported on an association of WPS with nasopharyngeal cancer and found no significant relationship between the two (OR= 0.49, 95% CI 0.20–1.23). Similarly, WPS was not found to be significantly associated with pancreatic and prostate cancers (Lo et al., 2007; Hosseini et al., 2010).

Discussion

The present paper systematically reviews the published data on the relationship of WPS with different cancers. Although, there have been a few reviews on the topic, all of them have reported overall health effects of WSP without being cancer specific. Tobacco being an established risk factor for a number of cancers and WPS being a tobacco-related product, it is imperative to systematically investigate the association of WPS with cancers. Moreover, in contrast to previous reviews, in our study we used the Cochrane Collaboration methodology to ensure overall quality of the included studies. This included a precise and systematic search strategy, a duplicate and independent selection and data abstraction process and a thorough assessment of the methodological quality of included studies.

We carried out an assessment of the current published data to prove or disprove the potential harmful effects of WPS and highlight loopholes to focus on the future work. The available evidence showed a significant association of WPS with lung cancer; however, no association was observed with bladder, nasopharyngeal, pancreatic and prostate cancers. Gastric and oesophageal cancers were observed to have weak associations with WPS. Interestingly, our search did not yield any study that evaluated the risk of oral cancer in WPS users.

Waterpipe smoke contains a number of toxicants and carcinogens that are known to be associated with addiction and other diseases in cigarette smokers (Table 2). Exposure of these harmful chemicals such as nicotine, CO, PAHs and/or TSNAs among waterpipe smokers has been meticulously investigated (Eissenberg and Shihadeh, 2009; Jacob et al., 2011; Jacob et al., 2013; Bentur et al. 2014; Helen et al., 2014; Al Ali et al., 2015; Shihadeh et al., 2015). Studies have shown an overall significant uptake of these compounds in waterpipe smokers. In addition, waterpipe smokers compared to cigarette smokers showed a significant exposure to CO and PAHs. However, exposure to nicotine and TSNAs was found to be similar to significant low when compared to cigarette smokers.

Dose response for the risk of cancer associated with WPS is difficult to calculate in contrast to dose response for cigarette exposure; latter can be calculated using the pack years. Moreover, published data on dose-related cancer risk for WPS is scarce, as only a few studies have reported dose response for waterpipe exposure. Dar et al. (2012) in their study assessed the dose response for WPS and oesophageal cancer using never smokers as a comparison group. They reported that those who smoked 1–139, 140–240 and more than 240 hookah-years had respective risks of 1.12 (95 % CI 0.77–1.64), 1.54 (95 % CI 1.05–2.26) and 3.62 (95 % CI 2.50–5.23) to develop esophageal cancer (P for trend <0.0001).

Although, our search did not yield any study that evaluated WPS associated risk of oral cancer, a probable relationship may still exists. Presence of a number of toxicants and carcinogens in waterpipe smoke that are similar to those found in cigarette smoke and are strongly associated with oral carcinogenesis provide some evidence towards a plausible association of WPS and oral cancer. Unfortunately, no published data have emerged to estimate the risk of oral cancer in WPS users (Warnakulasuriya, 2011).

In our review, the quality of evidence was low as most of the studies had methodological flaws. The majority of studies did not control for concomitant cigarette and other tobacco smoking. Moreover, most of the studies were case-control with some being exclusively hospital-based and lack adjustments of the cofounding factors. Absences of a standardized exposure assessment tool, poor sampling methods, and limited assessment of gender and age as cofounders, were some of the other limitations observed in studies (Maziak et al., 2005; Raad et al., 2011).

Another methodological flaw that affected the quality of the evidence was the lack of reporting the specific type of tobacco used. The studies that reported the association of WPS with lung cancer were mostly conducted in China and India, a place where unprocessed tobacco is usually consumed by directly burning with charcoal. On the contrary, the recent global epidemic of WPS involves processed and flavored tobacco that is consumed by indirect heating with the charcoal.

To overcome these limitations and to appropriately evaluate the longstanding health hazards of WPS, larger well-designed, prospective, population-based cohort studies are required. Furthermore, these studies should also look into puffing parameters, duration of WPS and effects of passive WPS, areas that have been neglected. Although, cohort studies are a gold standard to assess the incidence of a disease in exposure groups, they are expensive and time consuming and may require follow-up of large numbers of subjects for a long period of time. In mean time, evidence from well-structured systematic reviews of the available data would give confidence to the public health policy makers to devote their efforts and resources towards countering the health-related ill effects of WPS.

Regardless of the limitations, there is sufficient evidence to suggest the association of WPS with cancer outcome particularly lung cancer. This knowledge ought to be utilized to better educate the general public in order to dissipate the perception of its safe use, and outline public health strategies and specific research work.

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