The effects of waterpipe tobacco smoking on health outcomes: an updated systematic review and meta-analysis

Article in International Journal of Epidemiology · April 2016
DOI: 10.1093/ije/dyw021

5 authors, including:

Reem Waziry
UNSW Australia
10 PUBLICATIONS 2 CITATIONS

Mohammed Jawad
Imperial College London
62 PUBLICATIONS 349 CITATIONS

Elie Akl
American University of Beirut
420 PUBLICATIONS 12,055 CITATIONS

Some of the authors of this publication are also working on these related projects:

Interactions with pharmaceutical companies View project

Pharmaceutical Company-Physician-Pharmacist Relationship View project

All content following this page was uploaded by Reem Waziry on 28 April 2016.

The user has requested enhancement of the downloaded file. All in-text references underlined in blue are added to the original document and are linked to publications on ResearchGate, letting you access and read them immediately.
The effects of waterpipe tobacco smoking on health outcomes: an updated systematic review and meta-analysis

Reem Waziry,1,2 Mohammed Jawad,3,4 Rami A. Ballout,5 Mohammad Al Akel1 and Elie A Akl6,7*

1Faculty of Health Sciences, American University of Beirut, Beirut, Lebanon, 2Kirby Institute, University of New South Wales, Sydney, NSW, Australia, 3Department of Primary Care and Public Health, Imperial College London, London, UK, 4Academic Department of Primary Care and Population Sciences, University of Southampton, Southampton, UK, 5Faculty of Medicine, American University of Beirut, Beirut, Lebanon, 6Department of Internal Medicine, American University of Beirut, Beirut, Lebanon and 7Department of Clinical Epidemiology & Biostatistics, McMaster University, Hamilton, ON, Canada

*Corresponding author. Department of Internal Medicine, American University of Beirut Medical Center, P.O. Box: 11-0236, Riad-El-Solh Beirut 1107 2020, Beirut, Lebanon. E-mail: ea32@aub.edu.lb

Accepted 20 January 2016

Abstract

Background and aims: A systematic review conducted in 2008 found significant associations between waterpipe tobacco smoking and lung cancer, respiratory disease, periodontal disease and low birthweight. Since then, a number of relevant studies have been published. The objective of this study was to update the systematic review on the effects of waterpipe tobacco smoking on health outcomes.

Methods: In May 2015 we electronically searched the following databases with no date restrictions: MEDLINE, EMBASE and the ISI Web of Science using a detailed search strategy with no language restrictions. We also screened the references’ lists of the included studies. We included cohort, case-control and cross-sectional studies, and excluded case reports, conference abstracts, editorials and reviews. We excluded studies not conducted in humans, assessing physiological outcomes, not distinguishing waterpipe tobacco smoking from other forms of smoking or not reporting association measures. We assessed risk of bias for each included study and conducted meta-analyses for each of the outcomes of interest.

Results: We identified 50 eligible studies. We found that waterpipe tobacco smoking was significantly associated with: respiratory diseases [COPD; odds ratio (OR) = 3.18, 95% confidence interval CI = 1.25, 8.08; bronchitis OR = 2.37, 95% CI = 1.49, 3.77; passive waterpipe smoking and wheeze OR) = 1.97, 95% CI 1.28, 3.04]; oral cancer OR = 4.17, 95% CI = 2.53, 6.89; lung cancer OR = 2.12, 95% CI = 1.32, 3.42; low birthweight (OR = 2.39, 95% CI = 1.32, 4.32); metabolic syndrome (OR 1.63–1.95, 95% CI = 1.25, 2.45); cardiovascular disease (OR = 1.67, 95% CI = 1.25, 2.24); and mental health (OR 1.30–2.4,
95% CI = 1.20, 2.80). Waterpipe tobacco smoking was not significantly associated with: oesophageal cancer (OR = 4.14, 95% CI = 0.93, 18.46); worse quality of life scores [standardized mean difference (SMD) = -0.16, 95% CI = -0.66, 0.34]; gastric carcinoma (OR = 2.16, 95% CI = 0.72, 6.47); bladder cancer (OR = 1.25, 95% CI = 0.99, 1.57); prostate cancer (OR = 7.00, 95% CI = 0.90, 56.90); hepatitis C infection (OR = 0.98, 95% CI = 0.80, 1.21); periodontal disease (OR = 3.00, 5.00); gastro-oesophageal reflux disease (OR = 1.25, 95% CI = 1.01, 1.56); nasopharyngeal carcinoma (OR = 0.49, 95% CI = 0.20, 1.23); bladder cancer (OR = 1.25, 95% CI = 0.99, 1.57); infertility (OR = 2.50, 95% CI = 1.00, 6.30); and mortality (OR = 1.15, 95% CI = 0.93, 1.43).

Conclusions: There is accumulating evidence about the association of waterpipe tobacco smoking with a growing number of health outcomes.

Key words: Waterpipe tobacco smoking, health effects, systematic review

Background

The past decade has witnessed a steady increase in waterpipe tobacco smoking, especially among the younger age groups. A systematic review found that school and university students have the highest prevalence of waterpipe tobacco smoking across countries. In the Global Adult Tobacco Survey conducted in 13 low- and middle-income countries, the prevalence of waterpipe use among men was highest in Vietnam (13%) and Egypt (6.2%). Among women, waterpipe use was highest in Russia (3.2%) and Ukraine (1.1%). Even though the Middle Eastern youth are affected the most by the waterpipe smoking epidemic, over the past two decades many studies have reported increase in waterpipe use among youth in North America and Europe.

We systematically reviewed the literature in 2008 and found significant associations between waterpipe tobacco smoking and a number of health outcomes. For example, waterpipe tobacco smoking was associated with increased odds of lung cancer [odds ratio (OR) = 2.12] and respiratory disease (OR = 2.30). We also found evidence suggesting clinically significant association with periodontal disease (OR = 3–5) and low birthweight (OR = 2.12).

The available evidence at that time did not allow ruling out or confirming an association between waterpipe tobacco smoking and bladder cancer, nasopharyngeal cancer, oesophageal cancer, oral dysplasia and infertility. Since then, newly published studies have addressed some of these outcomes (e.g. oesophageal carcinoma) as well as additional outcomes [e.g. quality of life, cardiovascular diseases, gastro-oesophageal reflux disease (GERD)]. Therefore, the objective of this study was to update our systematic review of the medical literature on the effects of waterpipe tobacco smoking on health outcomes.

Methods

Eligibility criteria

We included observational studies (i.e. cohort studies, case-control studies and cross-sectional studies). The exposure of interest was waterpipe tobacco smoking and the outcomes of interest were any health outcomes. We excluded: case reports; case series; outbreak investigations; and abstracts. We also excluded studies: assessing waterpipe use for non-tobacco smoking purposes (e.g. marijuana smoking and other recreational drug use); not distinguishing waterpipe tobacco smoking from other forms of smoking; assessing physiological [e.g. forced expiratory volume in 1 s (FEV1)] or other surrogate outcomes (e.g., artery occlusion); and not reporting any measure of association.

Key Messages

• Waterpipe tobacco smoking is likely associated with oral cancer and lung cancer.
• It is also likely associated with respiratory diseases, low birthweight, metabolic syndrome, cardiovascular disease and mental health.
• Waterpipe tobacco smoking is likely not associated with oesophageal cancer, gastric carcinoma, bladder cancer or prostate cancer.
• It is also likely not associated with hepatitis C infection, periodontal disease, gastro-oesophageal reflux disease, infertility or mortality.
Search strategy

In May 2015, we updated the literature search originally conducted in June 2008. We used the OVID interface to electronically search MEDLINE (1950 onwards) and EMBASE (1980 onwards). We also searched the ISI Web of Science. Appendix 1 & Appendix 2 (available as Supplementary data at IJE online) presents our detailed search strategy. We designed the search strategy based on extensive internet search for waterpipe synonyms, and the search strategy used by Akl et al. The strategy consisted of the synonyms for waterpipe (e.g. 13 synonyms in the Medline strategy) but did not include any study design filter and was not restricted to any language. Two medical librarians reviewed and provided input on the search strategy. Additional search strategies included: (i) a review of the reference lists of included studies; (ii) the use of the ‘Related citations’ feature in PubMed; and (iii) an ongoing surveillance of the literature in place while updating the manuscript.

Selection process

Teams of two reviewers independently screened the title and abstract of identified citations for potential eligibility. We acquired the full texts of citations judged as potentially eligible by at least one of two reviewers. Next, two reviewers used a standardized and pilot-tested form to independently screen each full text for eligibility. Disagreements were resolved by discussion or by consulting a third reviewer.

Data abstraction

Teams of two reviewers used a standardized and pilot-tested form to independently abstract data. Disagreements were resolved by discussion or by consulting a third reviewer. Data abstracted from individual studies included information about study design, population, exposure, outcomes, methodological features, results and funding.

Risk of bias assessment

We have assessed the risk of bias of all the included studies based on the following four commonly used criteria: selection bias; information bias; confounding; and completeness of data. The risk of bias was rated as ‘high’ in studies that failed three or more of these criteria, ‘moderate’ in studies that failed one or two criteria and ‘low’ in studies that failed none of them. To assess selection bias, we reviewed sampling of participants, their recruitment and their representativeness. We have assessed information bias for measurement of exposure and outcome with regard to using validated tools with adequate evidence of validation provided. Confounding assessment was based on whether authors reported controlling for relevant confounders with adequate details (e.g. in the design phase through matching and/or in the analysis through adjustment). Completeness of data was based on whether authors provided information about missing data and participation rate (Appendix 3 & Appendix 4, available as Supplementary data at IJE online).

Data analysis

Agreement between the reviewers was calculated using Cohen’s kappa statistic. We conducted meta-analyses for the outcomes for which at least two studies reported effect estimates of their association with waterpipe tobacco smoking. When a study reported more than one relevant effect estimate, we selected the one that adjusted for the maximum number of confounders, particularly for other forms of tobacco smoking.

For continuous outcomes using different scales, we calculated the standardized mean difference (SMD) for each study and then pooled across eligible studies using the inverse variance method. For dichotomous outcomes, we used the reported ORs to calculate the Natural logarithm of odds ratios (ln(ORs)) and standard errors. We then pooled the ln(ORs) across eligible studies using the inverse variance method. We used fixed-effects models when pooling only two studies, and used the random-effects model in all other cases. We measured heterogeneity across studies using the I² statistic. We considered heterogeneity to be high when I² was greater than 50%. We used Review Manager software Version 5.0.2 for all analyses.

Results

Search results

Appendix 1 shows the study flow. Out of 360 full texts assessed, we excluded 301, with reasons for exclusion provided in Appendix 1. Of the 50 included studies, 24 were identified by the original search and 26 were identified by the update. Agreement between reviewers for study eligibility was excellent (kappa = 0.94 and 0.80 for the two teams).

The included studies assessed the associations between waterpipe tobacco smoking and the following outcomes: respiratory diseases (n = 9); quality of life (n = 2); oesophageal cancer (n = 3); gastric carcinoma (n = 3); oral cancer (n = 3); bladder cancer (n = 2); nasopharyngeal cancer (n = 1); lung cancer (n = 6); prostate cancer (n = 1); colorectal cancer (n = 1); pregnancy outcomes (n = 3); periodontal disease (n = 6); hepatitis C infection (n = 3);
infertility (n = 1); metabolic syndrome (n = 1); gastroesophageal reflux disease (GERD) (n = 1); cardiovascular diseases (n = 2); mental health (n = 1); and mortality outcomes (n = 1).

Methodological features

Risk of bias assessment
Out of the 50 included studies, only 8 studies were assessed to have selection bias and/or report insufficient information about the sampling techniques, and 16 studies reported the participation rate. There was no agreement across studies on a standardized way to measure exposure to waterpipe tobacco smoking, and this was the main reason for heterogeneity in the meta-analysis. There was agreement across studies on the need to adjust for potential confounders such as age, gender, education and other forms of tobacco use.

Evidence synthesis

Respiratory diseases
Nine studies evaluated the association between waterpipe tobacco smoking and respiratory disease. Five studies assessed the association between waterpipe tobacco smoking and chronic obstructive pulmonary disease (COPD) (four cross-sectional studies and one case-control) (Table 1; Appendix 3: Table 1 & Figure 1). The pooled odds ratios for the association of waterpipe tobacco smoking and COPD was OR = 3.18, (95% CI = 1.25, 8.08; I² = 95%). Two studies assessed the association between waterpipe tobacco smoking and bronchitis (two cross-sectional studies) (Table 1; Appendix 3: Table 1 & Figure 2). The pooled odds ratios for the association of waterpipe tobacco smoking and bronchitis was OR = 2.37, (95% CI = 1.49, 3.77).

Two cross sectional studies evaluated the association between passive waterpipe tobacco smoking and respiratory illness (defined as nasal congestion and wheezing) (Table 1; Appendix 3: Table 1 & Figure 3). The pooled odds ratio for the association of passive waterpipe tobacco smoking and respiratory illness was 1.97 (95% CI = 1.28, 3.04).

Quality of life
Two cross-sectional studies evaluated the association between waterpipe tobacco smoking and quality of life (Table 1; Appendix 3: Table 2 & Figure 4). One found that waterpipe smokers have a poorer respiratory quality of life, using the Clinical COPD Questionnaire (CCQ) and the MRC dyspnoea scale. Another found that waterpipe smokers have a higher risk for poorer health-related quality of life with regard to physical function, bodily pain, general health, mental health, vitality and social function on the Short Form Health Survey (SF-36). They also found a higher risk on the Mental Component Score (MCS) and Physical Component Score (PCS). The pooled standardized mean difference (SMD) was -0.16 (95% CI = -0.66, 0.34; I² = 93%).

Cancer outcomes

Oesophageal cancer
Three case-control studies evaluated the association between waterpipe tobacco smoking and oesophageal cancer: one from Iran and two from Kashmir (Table 1; Appendix 3: Table 3 & Figure 5). The pooled odds ratios for the association of waterpipe tobacco smoking with oesophageal cancer was OR = 4.14 (95% CI = 0.93, 18.46). The level of statistical heterogeneity was high (I² = 96%).

Gastric carcinoma
Two case-control studies and one prospective cohort study evaluated the association between waterpipe tobacco smoking and gastric carcinoma (Table 1; Appendix 3: Table 3 & Figure 6). Both studies were from Iran. The pooled odds ratio for the association of waterpipe tobacco smoking with gastric carcinoma was OR = 2.16 (95% CI = 0.72, 6.47). The level of statistical heterogeneity was high (I² = 61%). One case-control study reported only means, so was not included in the meta-analysis. It reported higher frequency of waterpipe smoking among those with gastric carcinoma (mean = 3 ± 1.6) compared with healthy controls (mean = 2 ± 1.1; P-value = 0.4).

Oral cancer
Three cross-sectional studies evaluated the association between waterpipe tobacco smoking and oral cancer: one from Yemen and one from India. The pooled odds ratio for the association of waterpipe tobacco smoking with oral cancer was OR = 4.17 (95% CI = 2.53, 6.89) (Table 1; Appendix 3: Table 3 & Figure 7).

Bladder cancer
Two case-control studies evaluated the association between waterpipe tobacco smoking and bladder cancer, both of which were conducted in Egypt (Table 1; Appendix 3: Table 3 & Figure 8). The pooled odds ratios for the association of waterpipe tobacco smoking with bladder cancer was OR = 1.25 (95% CI = 0.99, 1.57).
<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tamim 2003(^{18})</td>
<td>Cross-sectional</td>
<td>143</td>
<td>Wheezes/passive</td>
<td>2.30 (1.10, 5.10)</td>
</tr>
<tr>
<td>2</td>
<td>Mohammed 2013(^{5})</td>
<td>Cross-sectional</td>
<td>788</td>
<td>COPD</td>
<td>2.60 (0.60, 11.50)</td>
</tr>
<tr>
<td>3</td>
<td>Mohammed 2008(^{19})</td>
<td>Cross-sectional</td>
<td>77</td>
<td>COPD</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>Tageldine 2012(^{20})</td>
<td>Cross-sectional</td>
<td>61551</td>
<td>COPD</td>
<td>1.42 (1.12, 1.80)</td>
</tr>
<tr>
<td>5</td>
<td>Salameh 2012(^{21})</td>
<td>Case-control</td>
<td>211 cases 527 controls</td>
<td>Bronchitis</td>
<td>6.40 (2.55, 16.11)</td>
</tr>
<tr>
<td>6</td>
<td>Waked 2011(^{22})</td>
<td>Cross-sectional</td>
<td>425</td>
<td>COPD</td>
<td>2.53 (1.83, 3.50)</td>
</tr>
<tr>
<td>7</td>
<td>Waked 2009(^{23})</td>
<td>Cross-sectional</td>
<td>1268315</td>
<td>Bronchitis</td>
<td>1.95 (0.96, 8.08)</td>
</tr>
<tr>
<td>8</td>
<td>Mohammed 2014(^{24})</td>
<td>Cross-sectional</td>
<td>2734</td>
<td>Wheezes/passive</td>
<td>2.05 (1.01, 4.17)</td>
</tr>
<tr>
<td>9</td>
<td>She 2014(^{25})</td>
<td>Cross-sectional</td>
<td>1238</td>
<td>COPD</td>
<td>10.61 (6.89, 16.34)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Tavafian 2009(^{13})</td>
<td>Cross-sectional</td>
<td>1675</td>
<td>Quality of life Physical</td>
<td>2.15 (1.56, 2.96)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mental</td>
<td>1.88 (1.36, 2.60)</td>
</tr>
<tr>
<td>11</td>
<td>Joseph 2012(^{26})</td>
<td>Cross-sectional</td>
<td>2201</td>
<td>Quality of life</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>Malik 2010(^{27})</td>
<td>Case-control</td>
<td>135 cases 195 controls</td>
<td>Oesophageal</td>
<td>21.44 (11.63, 39.54)</td>
</tr>
<tr>
<td>13</td>
<td>Dar 2012(^{11})</td>
<td>Case-control</td>
<td>702 cases 1663 controls</td>
<td>Oesophageal</td>
<td>1.85 (1.41, 2.44)</td>
</tr>
<tr>
<td>14</td>
<td>Nasroallahzadeh 2008(^{12})</td>
<td>Case-control</td>
<td>300 cases 571 controls</td>
<td>Oesophageal</td>
<td>1.69 (0.76, 3.77)</td>
</tr>
<tr>
<td>15</td>
<td>Hosseini 2009(^{28})</td>
<td>Case-control</td>
<td>300 cases 571 controls</td>
<td>Prostate</td>
<td>7.00 (0.90, 56.9)</td>
</tr>
<tr>
<td>16</td>
<td>Sadjadi 2014(^{29})</td>
<td>Cohort</td>
<td>928</td>
<td>Gastric</td>
<td>3.44 (1.66, 7.11)</td>
</tr>
<tr>
<td>17</td>
<td>Shakeri 2013(^{30})</td>
<td>Case-control</td>
<td>309 cases 613 controls</td>
<td>Gastric</td>
<td>1.10 (0.30, 3.30)</td>
</tr>
<tr>
<td>18</td>
<td>Karajibani 2014(^{31})</td>
<td>Case-control</td>
<td>50 cases 46 controls</td>
<td>Gastric</td>
<td>N/A</td>
</tr>
<tr>
<td>19</td>
<td>Zheng 2012(^{32})</td>
<td>Case-control</td>
<td>1886 cases 2716 controls</td>
<td>Bladder Urothelial carcinoma:</td>
<td>1.30 (1.00, 1.80)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SCC:</td>
<td>1.20 (0.80, 1.70)</td>
</tr>
<tr>
<td>20</td>
<td>Bedwani 1997(^{33})</td>
<td>Case-control</td>
<td>151 cases 157 controls</td>
<td>Bladder</td>
<td>0.80 (0.20, 4.00)</td>
</tr>
<tr>
<td>21</td>
<td>Qiao 1989(^{34})</td>
<td>Case-control</td>
<td>107 cases 107 controls</td>
<td>Lung</td>
<td>1.90 (0.40, 9.40)</td>
</tr>
<tr>
<td>22</td>
<td>Lubin 1990(^{35})</td>
<td>Case-control</td>
<td>74 cases 74 controls</td>
<td>Lung</td>
<td>3.60</td>
</tr>
<tr>
<td>23</td>
<td>Lubin 1992(^{36})</td>
<td>Case-control</td>
<td>427 cases 1011 controls</td>
<td>Lung</td>
<td>1.80 (0.80, 4.20)</td>
</tr>
<tr>
<td>24</td>
<td>Hsairi 1993(^{37})</td>
<td>Case-control</td>
<td>110 cases 110 controls</td>
<td>Lung</td>
<td>3.00 (1.20, 7.6)</td>
</tr>
<tr>
<td>25</td>
<td>Gupta 2001(^{18})</td>
<td>Case-control</td>
<td>265 cases 525 controls</td>
<td>Lung</td>
<td>1.94 (0.85, 4.44)</td>
</tr>
<tr>
<td>26</td>
<td>Hazleton 2001(^{39})</td>
<td>Cohort</td>
<td>1289 WP only 2306 WP/cigarettes 8416 non-smokers</td>
<td>Lung</td>
<td>RR 4.39 (3.82, 5.04)</td>
</tr>
</tbody>
</table>

(continued)
Table 1. Continued

<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Feng 2009</td>
<td>Case-control</td>
<td>636 cases 615 controls</td>
<td>Nasopharyngeal</td>
<td>0.49 (0.20, 1.23)</td>
</tr>
<tr>
<td>28</td>
<td>Ali 2007</td>
<td>Cross-sectional</td>
<td>33</td>
<td>Oral</td>
<td>8.33 (0.78, 9.47)</td>
</tr>
<tr>
<td>29</td>
<td>Dangi 2012</td>
<td>Cross-sectional</td>
<td>761</td>
<td>Oral</td>
<td>4.42 (2.32, 8.41)</td>
</tr>
<tr>
<td>30</td>
<td>Schmidt-Westhausen 2014</td>
<td>Cross-sectional</td>
<td>162</td>
<td>Oral</td>
<td>4.35 (1.73, 10.93)</td>
</tr>
<tr>
<td>31</td>
<td>Nikbakht 2015</td>
<td>Cross-sectional</td>
<td>120</td>
<td>Colorectal</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Pregnancy outcomes

<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>Nuwayhid 1998</td>
<td>Retrospective cohort</td>
<td>895</td>
<td>Low birthweight</td>
<td>2.17 (0.74, 6.33)</td>
</tr>
<tr>
<td>33</td>
<td>Aghamolaei 2007</td>
<td>Case-control</td>
<td>60 cases 60 controls</td>
<td>IUGR</td>
<td>3.50 (1.1, 12.6)</td>
</tr>
<tr>
<td>34</td>
<td>Tamim 2008</td>
<td>Retrospective cohort</td>
<td>1391</td>
<td>Low birth weight</td>
<td>1.20 (0.60, 2.20)</td>
</tr>
<tr>
<td>35</td>
<td>Eftekhar 2007</td>
<td>Case-control</td>
<td>60 cases 60 controls</td>
<td>IUGR</td>
<td>3.50 (1.10, 12.60)</td>
</tr>
</tbody>
</table>

Periodontal disease

<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>Natto 2005</td>
<td>Cross-sectional</td>
<td>355</td>
<td>Periodontal disease</td>
<td>3.50 (1.6, 7.6)</td>
</tr>
<tr>
<td>37</td>
<td>Natto 2004</td>
<td>Cross-sectional</td>
<td>244</td>
<td>Periodontal disease</td>
<td>N/A</td>
</tr>
<tr>
<td>38</td>
<td>Baljoon 2005</td>
<td>Cross-sectional</td>
<td>262</td>
<td>Periodontal disease</td>
<td>2.90 (1.20, 7.00)</td>
</tr>
<tr>
<td>39</td>
<td>Al-Belasy 2004</td>
<td>Cohort</td>
<td>100</td>
<td>Dry socket</td>
<td>RR 3.00 (P-value 0.001)</td>
</tr>
</tbody>
</table>

Infectious diseases

<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Habib 2001</td>
<td>Cross-sectional</td>
<td>1827</td>
<td>HCV</td>
<td>1.10 (0.7, 1.5)</td>
</tr>
<tr>
<td>41</td>
<td>Medhat 2002</td>
<td>Cross-sectional</td>
<td>2717</td>
<td>HCV</td>
<td>0.90 (0.4, 2.0)</td>
</tr>
<tr>
<td>42</td>
<td>El-Sadawy 2004</td>
<td>Cross-sectional</td>
<td>782</td>
<td>HCV</td>
<td>1.02 (0.64, 1.62)</td>
</tr>
</tbody>
</table>

Infertility

<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>Inhorn 1994</td>
<td>Case-control</td>
<td>45</td>
<td>Infertility</td>
<td>2.50 (1.0, 6.3)</td>
</tr>
</tbody>
</table>

Digestive/GIT diseases

<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>Shafique 2012</td>
<td>Cross-sectional</td>
<td>30–75</td>
<td>Metabolic syndrome</td>
<td>1.63 (1.25, 2.10)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hypertriglycaemia</td>
<td>1.82 (1.37, 2.41)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hypertension</td>
<td>1.95 (1.52, 2.45)</td>
</tr>
<tr>
<td>45</td>
<td>Islami 2014</td>
<td>Cross-sectional</td>
<td>75</td>
<td>GERD</td>
<td>1.34 (1.02, 1.75)</td>
</tr>
</tbody>
</table>

Cardiovascular disease

<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>Al-Suwaidi 2012</td>
<td>Cohort</td>
<td>7939</td>
<td>ACS</td>
<td>N/A</td>
</tr>
<tr>
<td>47</td>
<td>Islami 2012</td>
<td>Cross-sectional</td>
<td>75</td>
<td>CVD</td>
<td>3.75 (1.52, 9.22)</td>
</tr>
</tbody>
</table>

Mental health

<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>Primack 2013</td>
<td>Cross-sectional</td>
<td>100891</td>
<td>Mental health</td>
<td>1.40 (1.30, 1.50)</td>
</tr>
</tbody>
</table>

Mortality

<table>
<thead>
<tr>
<th>ID</th>
<th>Study</th>
<th>Design</th>
<th>Participants(N)</th>
<th>Outcome</th>
<th>Reported OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>Wu 2013</td>
<td>Cohort</td>
<td>11746</td>
<td>Mortality</td>
<td>HR 1.15 (0.93, 1.43)</td>
</tr>
</tbody>
</table>

¶Excluding studies that did not fulfill the eligibility criteria.
WP, waterpipe; HCV, hepatitis C virus; RR, risk ratio; SCC, squamous cell carcinoma; N/A, not available; IUGR, intrauterine growth retardation; GIT, gastrointestinal tract; ACS, acute coronary syndrome; CVD, cardiovascular disease.
†Indicates two studies from the same population, thus grand total = 50 studies

Excluding studies that did not fulfill the eligibility criteria.
Nasopharyngeal cancer

One case-control study evaluated the association between waterpipe tobacco smoking and nasopharyngeal cancer in Tunisia, Morocco and Iran40 (Table 1; Appendix 3, Table 3). The OR for the association of waterpipe tobacco smoking with nasopharyngeal cancer was 0.49 (95% CI = 0.20, 1.23).

Lung cancer

Five of six eligible studies were case-control studies measuring lung cancer diagnosis,34,36,38,60,61 and one was a retrospective cohort study measuring lung cancer mortality39 (Table 1; Appendix 3: Table 3 & Figure 9). One was conducted in Northern India, one was conducted in Tunisia and four reported data from the same population in China. Although nowadays waterpipe tobacco is processed, flavoured and indirectly heated by charcoal, in most of the included studies (those conducted in China and India) tobacco was typically unprocessed and burned directly by charcoal.

The pooled OR for the association of waterpipe tobacco smoking with lung cancer diagnosis was 2.12 (95% CI = 1.32, 3.42; I² = 0%) (Table 1; Appendix 3: Table 3 & Figure 9). The calculated crude risk ratio (RR) for the association with lung cancer mortality was 4.39 (3.82–5.04). A sensitivity analysis restricted to one study with no major methodological limitations produced an OR of 3.00 (95% CI = 1.20, 7.60).60

Prostate cancer

One case control study assessed the association between waterpipe tobacco smoking and prostate cancer.28 A sample of 137 male participants from Northern Iran, who were histologically confirmed with prostate cancer, were included in the study. The OR for the association between waterpipe tobacco smoking and prostate cancer was 7.00 (95% CI = 0.90, 56.90) (Table 1; Appendix 3, Table 3).

Colorectal cancer

One cross-sectional study assessed the association between waterpipe smoking and colorectal cancer.44 A sample of 120 participants who were recorded on the cancer registry centre of Babol were contacted to fill in a survey about demographics and risk factors including waterpipe use. Among waterpipe smokers, 22.70% of men and 15.80% of women were diagnosed with colorectal-cancer (Table 1; Appendix 3, Table 3).

Pregnancy outcomes

Two retrospective cohort studies and two case-control studies evaluated the association between waterpipe smoking and pregnancy outcomes45–48 (Table 1; Appendix 3: Table 4 & Figure 10). One study also reported Apgar score, pulmonary problems, malformations and perinatal complications.46 The pooled OR for the association of waterpipe tobacco smoking with low birthweight was 2.39 (95% CI = 1.32, 4.32; I² = 0%). The reported OR for the association of waterpipe tobacco smoking with newborn pulmonary problems was OR = 3.65 (95% CI = 1.52, 8.75). The associations were not significant for Apgar scores at 1 min and 5 min, malformations or perinatal complications.

Periodontal disease

Of the five studies that evaluated the association between waterpipe tobacco smoking and periodontal disease,49–53 four were cross-sectional studies conducted in the same (or in a subgroup of the same) group of participants.49–52 (Table 1; Appendix 3, Table 5). These four studies assessed periodontal disease using different measures (periodontal bone height loss, plaque index and gingivitis, deepening of the sulci or pockets, vertical periodontal bone loss). We did not pool data from the four related studies as they were derived from the same participants. Their results consistently showed a significant association of waterpipe tobacco smoking with periodontal disease (OR ranging 3.00–5.00).

The fifth study was a cohort study with 7 days’ follow-up after surgical removal of mandibular third molars, and evaluated the outcome of dry socket.53 The reported RR for the association of waterpipe tobacco smoking with dry socket was 3.70 (P = 0.001). Dry socket, or alveolar osteitis, is the most common complication following tooth extractions. It is caused by the dislodgement of the blood clot at the site of the tooth extraction, exposing underlying bone and nerves and causing increasing pain.

Infectious disease

Three cross-sectional studies evaluated the association between waterpipe tobacco smoking and hepatitis C.54–56 The three studies were conducted in Egypt and included male participants exposed to group waterpipe tobacco smoking (Table 1; Appendix 3: Table 6 & Figure 11). The pooled OR for the association of group waterpipe smoking with hepatitis C was 0.98 (95% CI = 0.80, 1.21). There were no eligible studies assessing the association between waterpipe tobacco smoking and the transmission of tuberculosis. The two reports that we found of outbreak investigations suggested an association between tuberculosis and sharing tobacco waterpipes and marijuana waterpipes.62,63

Infertility

One case-control study evaluated the association between waterpipe smoking and male factor infertility (based on
semen analysis)\(^5^7\) (Table 1; Appendix 3, Table 7). The reported OR for the association of waterpipe tobacco smoking with male factor infertility was \(OR = 2.50\) (95% CI = 1.00, 6.30).

**Metabolic syndrome**

One cross-sectional study evaluated the association between waterpipe tobacco smoking and metabolic syndrome.\(^5^8\) Waterpipe smokers were significantly more likely to have hypertriglyceridaemia (OR 1.63, 95% CI = 1.25, 2.10), hyperglycaemia (OR 1.82, 95% CI = 1.37, 2.41), hypertension (OR 1.95, 95% CI = 1.51, 2.51) and abdominal obesity (OR 1.93, 95% CI = 1.52, 2.45 (Table 1; Appendix 3, Table 8).

**Gastro-oesophageal reflux disease**

One cross-sectional study evaluated the association between waterpipe tobacco smoking and gastro-oesophageal reflux disease (GERD).\(^1^7\) The reported odds ratio for the association of waterpipe tobacco smoking with having any gastro-oesophageal reflux disease symptom was 1.25 (95% CI = 1.01, 1.56) (Table 1; Appendix 3, Table 8).

**Cardiovascular disease**

Two cross-sectional studies evaluated the association between waterpipe tobacco smoking and cardiovascular disease.\(^3^4,^1^6\) In one study, the reported odds ratio for the association between waterpipe tobacco smoking and heart disease was 1.67 (95% CI = 1.25, 2.24). The other study was based on data obtained from a population based cohort study conducted in the Golestan province in Iran, and included individuals between 40 and 75 years old. The reported OR for the association between waterpipe tobacco smoking and heart disease was 3.75 (95% CI = 1.55, 9.22) (Table 1; Appendix 3, Table 8).

**Mental health**

One cross-sectional study, conducted among institutions participating in the national college health assessment of the American College Health Association, evaluated the association between waterpipe tobacco smoking and mental health.\(^5^9\) All mental health diagnoses were significantly associated with increased rates of waterpipe tobacco smoking, with ORs ranging from 1.30 to 2.40 (Table 1; Appendix 3, Table 8).

**Mortality outcomes**

One cohort study associated waterpipe tobacco smoking with mortality outcomes.\(^1^5\) The first study, by Fen Wu et al., found that waterpipe tobacco smoking was significantly associated with increased risk of mortality from all causes (HR = 1.15; 95% CI 0.93, 1.43), cancer (HR = 1.30; 95% CI = 0.78, 2.18) and ischaemic heart disease (HR = 1.20, 95% CI = 0.87, 1.67) (Table 1; Appendix 3, Table 8).

**Discussion**

We systematically reviewed the medical literature for the effects of waterpipe tobacco smoking on health outcomes. We found that waterpipe tobacco smoking was associated with respiratory diseases (COPD, bronchitis and wheeze due to exposure to passive waterpipe smoking), oral cancer, lung cancer, low birthweight, metabolic syndrome, cardiovascular disease and mental health. The existing evidence suggested no association with oesophageal cancer, gastric carcinoma, bladder cancer, prostate cancer, hepatitis C infection, periodontal disease, gastro-oesophageal reflux disease, nasopharyngeal carcinoma, bladder cancer, infertility or mortality.

Cigarette smoking is known to be a major cause of respiratory diseases through promoting lung function loss and decreasing lung function rates.\(^6^4-^6^6\) In a similar manner, waterpipe smoking was associated with significant reduction in forced expiratory volume in 1 s (FEV-1) and forced vital capacity (FVC), by 4.04% and 1.38% respectively, compared with non waterpipe smokers.\(^6^7\) This suggests an obstructive mechanism, as was similarly reported by Chaouchi et al. who have shown that chronic use of a waterpipe with one or more smoking sessions per day can lead to COPD.\(^6^8\) This result is also in agreement with the reported estimates that tobacco smoking increases the risks of death from lung cancer or COPD by 20-fold.\(^6\) Another mechanism for the effect of waterpipe smoking on respiratory outcomes was found to be through the damage that it causes to the lung parenchyma and the associated inflammation of the Airways.\(^6^9,^7^0\)

Tobacco was found to be a source of 69 carcinogens and has been widely associated with increasing the risk of developing cancers and malignancies.\(^6,^7^1\) Thus, strong associations have been established between cigarette smoking and different cancers, particularly in the lungs and the digestive system.\(^6^5,^6^6,^7^2-^7^5\) These results can also be extended to include waterpipe smoking, as has been reported by a study of 56 chronic Pakistani waterpipe smokers that found markedly increased levels of carcinoembryonic antigen (CEA) as compared with non-smokers (\(P < 0.0001\)).\(^7^6\) CEA is known to be elevated in lung, pancreatic, uterine and breast cancers as well as in cases of chronic inflammation. Other studies also reported increased risk of carcinogenesis among waterpipe smokers due to genotoxic and clastogenic components in the waterpipe smoke, such as
tar and polycyclic aromatic hydrocarbons. This likely explains the association between waterpipe tobacco smoking and cancers outside the lung such as prostate cancer, an association previously shown between cigarette smoking and prostate cancer. There is also evidence that smoking induces hormonal changes in men that could affect the risk of prostate cancer.

The effects of tobacco on atherosclerosis have been attributed to various mechanisms that promote atherosclerosis and endothelial dysfunction. Cigarette smoking has been associated with cardiovascular disease through promoting atherosclerosis and being highly dose related. Similarly, a comparative double-blinded study done on 37 waterpipe smokers who reported smoking a waterpipe 2–5 times/month showed increased mean (± SEM) plasma nicotine concentration (3.6 ± 0.7 ng/ml) and heart rate (8.6 ± 1.4 bpm) as compared with placebo (0.1 ± 0.0 ng/ml; 1.3 ± 0.9 bpm), indicating that the effects of waterpipe smoking on cardiovascular outcomes are mediated by its nicotine content. Some studies also attributed the deleterious effects of waterpipe smoking on cardiovascular disease to in vivo oxidation injury and systemic inflammation that increases the likelihood of atherosclerosis and arrhythmia.

Strengths and limitations

To our knowledge, no systematic reviews have been conducted on the association between waterpipe smoking and health outcomes since our earlier review in 2010. Further strengths of the review include adhering to the Cochrane Collaboration methodology, which is considered the gold standard for systematically reviewing literature, using a sensitive search strategy and conducting screening and data extraction independently and in duplicate.

The confidence in the effects estimates in this systematic review is affected by a number of limitations. Indeed, five out of 11 meta-analyses suffered from a high degree of heterogeneity, namely oesophageal carcinoma, gastric carcinoma, low birthweight, COPD and quality of life. Also, Appendix 3 shows the methodological limitations of the included studies. Most of the studies used non-validated tools for measurement of waterpipe tobacco exposure, which is a major limitation given that the practice of waterpipe tobacco smoking can vary widely according to the quantity of tobacco used, the frequency and the length of the session.

We were not able to conduct meta-analyses for all outcomes. One reason was the high level of heterogeneity, as was the case for the quality of life outcome. Another reason was that we could not pool several outcomes derived from the same study, as was the case for the metabolic syndrome, nasopharyngeal carcinoma, gastro oesophageal reflux disease, mental health and mortality outcomes.

Additional research implications of our findings include the need for more research on this topic using validated tools for measurement of both the exposure and the outcome of interest. There is also a need to investigate the effect of second-hand exposure due to the amount of smoke generated by a waterpipe.

Our findings have both clinical and public health implications. Our findings reinforce the message that all forms of smoking are unsafe, and clinicians should be clear about delivering this unified message to patients. Given the available evidence, public health agents and policy makers need not wait for more evidence to enact and implement laws, and develop public health programmes to reduce waterpipe tobacco use, particularly among youth. This is particularly relevant given the emerging evidence that waterpipe tobacco smoking may predict cigarette initiation and thus serve as a gateway to cigarette smoking.

Supplementary Data

Supplementary data are available at IJE online.

Conflict of interest: None.

References


