Introduction
Exposure to indirect smoking from all sources is estimated to be responsible for the premature death of more than 600,000 people annually (1, 2). Due to the toxicity of hookah smoking, this habit is estimated to cause about 6 million deaths annually (2, 3), and the number of deaths is projected to exceed 8 million by 2030 (2).

Recently, the use of waterpipe has increased significantly, especially among teenagers and adolescents in the Middle Eastern, the Mediterranean, South American, North African, and South Asian countries such as United Arab Emirates, Egypt, Kuwait, Qatar, and Iran (1, 3-6). Despite available evidence of health risks, hookah smoking (sometimes called nargile, hookah, shisha, and ghalyune) has become a global epidemic because it is addictive in people of all genders and ages. The increasing worldwide waterpipe use has also attracted attention among adolescents and college students and has reached alarming levels (2). Unfortunately, many consumers mistakenly claim that hookah use is less toxic, addictive, and harmful than smoking cigarettes (2, 4). These people believe that the nicotine and toxic pollutants in the smoke are dissolved into the water inside the bowl and then the treated smoke is inhaled (4, 7). Therefore, hookah use is perceived as a culturally accepted practice and leisure activity in these groups (2).

Due to the increasing tendency of many people towards waterpipe cafés and also the inadequate ventilation in these places, they can act as common places for exposure to many types of pollutants. Tobacco smoke comprises thousands of toxic and hazardous compounds that are released as gaseous and particulate matter into the air of cafes (3). Particulate matter (PM10, PM2.5), nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs), volatile aldehydes (e.g., formaldehyde carcinogenic compound), polycyclic aromatic hydrocarbons (PAHs), nicotine, phenol, and furans, as well as heavy metals, are the main harmful contaminants in waterpipe smoke (4, 6, 8).

The use of waterpipe has grown significantly in recent years. Hookah use has been shown to be associated with various human health problems such as cardiovascular disease, respiratory disease, and cancer. The aim of this review study was to investigate the pollutants in the indoor air of waterpipe cafes. An automated literature search was conducted to identify any relevant studies published up to February 2022. For this search, international digital databases (PubMed, ScienceDirect, and Scopus) were chosen. Multiple keywords were used in the systematic literature review, including “hookah” OR “waterpipe” OR “hubble-bubble” OR “narghile” OR “shisha” AND “café” AND “indoor air.” After removing duplicate papers and analyzing titles, abstracts, and full texts, 25 studies remained for analysis and interpretation. Particulate matter, polycyclic aromatic hydrocarbons (PAH), BTEX compounds, carbon monoxide (CO), nicotine, aldehydes, and bioaerosols were found to be the most prevalent and challenging contaminants in the indoor air of waterpipe cafes. Because of the growing popularity of waterpipe use in cafes, particularly among young people and teenagers, and the high concentration of pollutants in this area, as well as the long-term presence of individuals in these areas, it is necessary for officials to adopt restrictive laws in these places.

Keywords: Waterpipe café, Environmental pollutants, Indoor air
when comparing a typical waterpipe smoking session to a cigarette smoking session, the amounts of tar, CO, and nicotine were found to be 36.0, 8.4, and 1.7 times higher, respectively (2). Additionally, waterpipe smoke emits four times the carcinogenic PAH, four times the volatile aldehydes, and 30 times the CO of a single cigarette (7). Furthermore, when compared to outdoor air, these contaminants are found at higher amounts in waterpipe cafés (6). For example, in a recent study by Fazlzadeh et al, the mean CO concentration in the indoor and outside air of the waterpipe café was found to be 24.75 and 2.65 ppm, respectively (9). Moreover, Zhang et al found that the PM2.5 concentration in the indoor air of waterpipe cafés (1419 µg/m³) was significantly higher than the concentration outside (80.5 µg/m³) (10).

Indoor air pollution from tobacco smoking (such as waterpipe smoking) has become a global public health challenge due to its toxicity, carcinogenicity, and cardiovascular effects (2). The health outcomes of tobacco use result from the interaction of the body with the dangerous and poisonous compounds found in tobacco smoke, which subsequently enter the human body via repeated puffs (3). As a result, higher indoor concentrations of these pollutants reduce the quality of the air in the café and put the consumers at serious risk of cardiovascular disease, lung cancer, bronchial asthma, and other respiratory illnesses (6, 8, 11). Waterpipe smoking poses a risk not only to users but also to others who are exposed to waterpipe smoke and charcoal emissions (2). Secondhand smoke from waterpipe (WP) is linked to a higher risk of respiratory disorders, lung cancer, poor birth weight, and periodontal disease in adults (1). According to the reasons mentioned, the aim of this study was to investigate the pollutants in the indoor air of waterpipe cafés.

**Materials and Methods**

**Search Strategy**

A computerized literature search was carried out to select all relevant studies published up to February 2022. International digital databases (PubMed, ScienceDirect, and Scopus) have been selected for search. The systematic literature review was performed using multiple keywords, including “hookah” OR “waterpipe” OR “hubble-bubble” OR “narghile” OR “shisha” AND “café” AND “indoor air”. We also searched for additional articles in the References section of the recorded articles. Articles were searched blindly by two reviewers and then screened by them. In cases of disagreement, they were referred to a third reviewer.

**Inclusion and Exclusion Criteria**

This review covers a wide range of papers. Only studies in which samples were obtained from the indoor air of a waterpipe café were included, while studies in which hookah smoke was extracted using a specific apparatus or electronic machine were ruled out. Studies that directly assessed tobacco or coal contaminants were also excluded. In terms of language, only articles written in English were included. Included studies were required to contain statistical indicators such as the mean and standard deviation, as well as the minimum and maximum pollutant concentrations.

**Data Extraction**

For included studies, data about the type of study, type of pollutants, type of tobacco, concentrations of pollutants, country, and year of the study were extracted and recorded.

**Results**

**Data Retrieval**

Figure 1 depicts a flow chart of the reviewing process. In the initial search of databases, 86 relevant studies were found. Following the removal of duplicate articles and reviewing of the titles, abstracts, and full texts, 25 studies were left for analysis and interpretation. Table 1 lists the characteristics of the studies included in the systematic review. According to the recommendation of the World Health Organization (WHO), in cases where the concentration of pollutants is less than the detection limit, its value is considered to be half the detection limit. In this study, only concentrations that were above the detection limit were reported.

**Discussion**

In 10 studies, the concentration of CO was measured in 35 waterpipe cafés (different cafés or similar cafés with different conditions, such as the different types of tobacco). WHO guideline values for indoor CO concentration are 100 mg/m³ for 15 minutes, 35 mg/m³ for 1 hour, 10 mg/m³ for 8 hours and 7 mg/m³ for exposure time. In 58.8% of cafés, the concentration of CO was higher than the standard value for 8 hours of exposure. In the study conducted by Fazlzadeh et al, the concentration of CO in the indoor air of cafés (17.2 ± 24.8 ppm) was significantly higher compared to outdoors (2.7 ± 1.3 ppm). The main possible sources of CO identified for the cafés include the waterpipe preparation process (burning coals), smoking practices, samovars (heated metal utensils used to heat and boil water), and gas stoves. CO is reported to comprise 0.34%-1.4% by volume of hookah smoke. The concentration of CO found in the indoor air of waterpipe cafés (i.e., 30.8 ppm) is significantly higher compared to traditional cafés (i.e., 8.9 ppm) where only cigarettes are used. Therefore, concurrently, tobacco smoking in confined indoor environments seems to be the most important source of CO emissions. Exposure to CO leads to various health effects by affecting the cardiovascular system, lungs, and blood and central nervous systems depending on the health and physiological status of the person exposed, the concentration of the contaminant, etc.
and the time of exposure.

In 5 studies, nicotine concentrations were examined in 17 cafes. The measured mean concentrations varied from 0.77 to 14 µg/m³. In none of the cafes, the measured concentrations of nicotine exceed the mentioned limit. The mean values of nicotine concentration reported by Masjedi et al were much lower for indoor air of waterpipe cafe (5.98 ± 2.42 µg/m³) compared to occupational standards announced by Occupational Safety and Health Administration (500 µg/m³). However, these standard values are applied to healthy workers and personnel and may not be applicable to sensitive people, including children, the elderly, and patients. In addition to its potential for addiction and as a gateway to the use of other tobacco products, nicotine has many harmful health complications including negative effects on the nervous system, impairment in the formation, survival, and differentiation of brain cells, low birth weight after exposure during pregnancy, hearing loss, tooth decay, and hyperactivity.

In 10 studies, the concentration of particulate matter (PM), mainly PM2.5, has been investigated. The number of times the suspended particles are measured in different cafes is 56. The annual guideline value of PM2.5 in indoor air is 10 µg/m³, which is determined by WHO. In all the cafes studied, the concentration of suspended
| Author/Reference | Year   | Country       | Type of Tobacco                        | N  | Type of Pollutants | Concentration | Unit       |
|-----------------|--------|---------------|----------------------------------------|----|--------------------|---------------|------------|
| Fazzlzadeh et al (9) | 2015   | Ardabil, Iran | Traditional Herbal (flavored)           | 55 | CO                 | 8.8           | ppm        |
|                 |        |               |                                        | 13 | CO                 | 28.5          | ppm        |
| Heydari et al (4)   | 2017-2018 | Tehran, Iran | Flavored, regular, fruit flavored      | 14 | PM10               | 627.79        | μg/m³      |
|                 |        |               |                                        |    | PM10               | 776.93        | μg/m³      |
|                 |        |               |                                        |    | PM2.5              | 249.07        | μg/m³      |
|                 |        |               |                                        |    | PM2.5              | 294.79        | μg/m³      |
| Naddafi et al (8)  | 2018   | Ardabil, Iran | Fruit-flavored (80%) regular (20%)    | 50 | PM10               | 765           | μg/m³      |
|                 |        |               |                                        |    | PM2.5              | 624           | μg/m³      |
|                 |        |               |                                        |    | PM1                | 500           | μg/m³      |
| Naddafi et al (12) | 2018   | Ardabil       |                                        | 50 | Bacteria           | 3.19          | CFU/m³     |
|                 |        |               |                                        |    | Fungi              | 25.24         | CFU/m³     |
| Rostami et al (13) | 2019   | Ardabil, Iran | Fruit-flavored, regular or traditional | 60 | CO                 | 12            | μg/m³      |
|                 |        |               |                                        |    | PM10               | 440.3         | μg/m³      |
|                 |        |               |                                        |    | PM2.5              | 303.3         | μg/m³      |
|                 |        |               |                                        |    | PM1                | 171.5         | μg/m³      |
| Al-Dabbous et al (2) | 2017   | Kuwait        |                                        | 1  | CO                 | 10.1          | Mg/m³      |
|                 |        |               |                                        |    | PM2.5              | -             | μg/m³      |
|                 |        |               |                                        |    | PM1                | -             | μg/m³      |
| Al Mulla et al (1) | 2012   | Doha, Qatar   |                                        | 40 | PM2.5              | 476.1         | μg/m³      |
| Hazzati et al (14)  | 2015   | Ardabil, Iran | Regular, fruit-flavored                | 81 | Benzene            | 4.96          | mg/m³      |
|                 |        |               |                                        |    | Toluene            | 4.86          | mg/m³      |
|                 |        |               |                                        |    | Ethylbenzene       | 4.38          | mg/m³      |
|                 |        |               |                                        |    | Xylene             | 6.69          | mg/m³      |
| Masjedi et al (15) | 2017-2018 | Tehran, Iran | Fruit-flavored, traditional            | 14 | PM10               | 488.1         | ng/m³      |
|                 |        |               |                                        |    | Pb                 | 541.7         | ng/m³      |
|                 |        |               |                                        |    | Pb                 | 541.7         | ng/m³      |
|                 |        |               |                                        |    | Cd                 | 21.71         | ng/m³      |
|                 |        |               |                                        |    | Cd                 | 21.71         | ng/m³      |
|                 |        |               |                                        |    | Cr                 | 40.51         | ng/m³      |
|                 |        |               |                                        |    | Cr                 | 40.51         | ng/m³      |
|                 |        |               |                                        |    | Ni                 | 73.57         | ng/m³      |
| Heydaria et al (16) | 2018-2019 | Bushehr, Iran | Fruit-flavored                          | 15 | Benzene            | 4.75          | mg/m³      |
|                 |        |               |                                        |    | Toluene            | 4.62          | mg/m³      |
|                 |        |               |                                        |    | Ethylbenzene       | 4.06          | mg/m³      |
|                 |        |               |                                        |    | Xylene             | 9.68          | mg/m³      |
|                 |        |               |                                        |    | Benzene            | 6.68          | mg/m³      |
|                 |        |               |                                        |    | Toluene            | 6.56          | mg/m³      |
|                 |        |               |                                        |    | Ethylbenzene       | 5.85          | mg/m³      |
|                 |        |               |                                        |    | Xylene             | 8.11          | mg/m³      |
|                 |        |               |                                        |    | Benzene            | 2.76          | mg/m³      |
|                 |        |               |                                        |    | Toluene            | 2.68          | mg/m³      |
|                 |        |               |                                        |    | Ethylbenzene       | 2.34          | mg/m³      |
|                 |        |               |                                        |    | Xylene             | 4.73          | mg/m³      |
|                 |        |               |                                        |    | Benzene            | 6.68          | mg/m³      |
|                 |        |               |                                        |    | Toluene            | 3.52          | mg/m³      |
|                 |        |               |                                        |    | Ethylbenzene       | 3.11          | mg/m³      |
| Deshpande et al (17) | 2008   | Mumbai, India |                                        | 2  | Pm2.5              | 973           | μg/m³      |
|                 | 2009   |               |                                        |    | Pm2.5              | 1267          | μg/m³      |
| Author/Reference | Year | Country | Type of Tobacco | N | Type of Pollutants | Concentration | Unit |
|------------------|------|---------|-----------------|---|-------------------|---------------|------|
| Travers et al (18) | 2017 | Central and western New York State | | 1 | PM2.5 | 617 | μg/m³ |
|                  |      |         |                 |   | CO | 37.4 | ppm |
|                  |      |         |                 |   | CO | 20.9 | ppm |
|                  |      |         |                 |   | PM2.5 | 593 | μg/m³ |
|                  |      |         |                 |   | CO | 15 | ppm |
|                  |      |         |                 |   | PM2.5 | 934 | μg/m³ |
|                  |      |         |                 |   | CO | 10.7 | ppm |
|                  |      |         |                 |   | CO | 1.5 | ppm |
|                  |      |         |                 |   | PM2.5 | 436 | μg/m³ |
|                  |      |         |                 |   | CO | 52.4 | ppm |
|                  |      |         |                 |   | CO | 5.5 | ppm |
|                  |      |         |                 |   | PM2.5 | 515 | μg/m³ |
|                  |      |         |                 |   | CO | 20.5 | ppm |
| Cobb et al (19) | 2011 | Virginia | | 1 | PM2.5 | 889 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 877 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 518 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 381 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 309 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 263 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 223 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 140 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 124 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 112 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 107 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 67 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 53 | μg/m³ |
|                  |      |         |                 |   | PM2.5 | 13 | μg/m³ |
| Feliu et al (20) | 2019 | Barcelona, Spain | | 20 | PM2.5 | 230.5 | μg/m³ |
|                  |      |         |                 |   | Nicotine | 1.15 | μg/m³ |
|                  |      |         |                 |   | Nicotine | 1.15 | μg/m³ |
|                  |      |         |                 |   | CO | 10.2 | ppm |
|                  |      |         |                 |   | CO | 11.4 | ppm |
|                  |      |         |                 |   | CO | 11.4 | ppm |
|                  |      |         |                 |   | PM2.5 | 430 | μg/m³ |
|                  |      |         |                 |   | CO | 6.9 | ppm |
|                  |      |         |                 |   | PM2.5 | 299 | μg/m³ |
|                  |      |         |                 |   | CO | 1.8 | ppm |
|                  |      |         |                 |   | PM2.5 | 59 | μg/m³ |
|                  |      |         |                 |   | CO | 3.1 | ppm |
|                  |      |         |                 |   | PM2.5 | 14 | μg/m³ |
|                  |      |         |                 |   | CO | 1.9 | ppm |
| Hammal et al (21) | 2013 | Edmonton, Alberta, Canada | | 1 | PM2.5 | 385 | μg/m³ |
|                  |      |         |                 |   | CO | 10.2 | ppm |
|                  |      |         |                 |   | CO | 11.4 | ppm |
|                  |      |         |                 |   | CO | 11.4 | ppm |
|                  |      |         |                 |   | PM2.5 | 430 | μg/m³ |
|                  |      |         |                 |   | CO | 6.9 | ppm |
|                  |      |         |                 |   | PM2.5 | 299 | μg/m³ |
|                  |      |         |                 |   | CO | 1.8 | ppm |
|                  |      |         |                 |   | PM2.5 | 59 | μg/m³ |
|                  |      |         |                 |   | CO | 3.1 | ppm |
|                  |      |         |                 |   | PM2.5 | 14 | μg/m³ |
|                  |      |         |                 |   | CO | 1.9 | ppm |
Table 1. Continued

| Author/Reference | Year | Country | Type of Tobacco | N | Type of Pollutants | Concentration | Unit |
|------------------|------|---------|-----------------|---|-------------------|---------------|------|
|                   |      |         |                |   |                   | Mean | SD  | Min | Max |
| Ghaffari et al   | 2021 |         |                |   |                   |      |      |     |     |
| Torrey et al     | 2011-2012 | Baltimore, USA | 1 | PM2.5 | 788 | 540 | 3799 | μg/m^3 |
| Loffredo et al   | 2005-2006 | Cairo and Giza, Egypt | 15 | Pm2.5 | 478.4 | 225.2 | 100 | 1313 | μg/m^3 |
| Naddafi et al    | 2018 | Ardabil, Iran | Fruit-flavored | 1 | Formaldehyde | 151.1 | 67 | 40.7 | 265.8 | μg/m^3 |
|                  |      |         | Regular        | 1 |        | 60 | 21.4 | 11 | 106.1 | μg/m^3 |
|                  |      |         | Total          | 1 |        | 123.7 | 70.9 | 31 | 265.8 | μg/m^3 |
|                  |      |         | Fruit-flavored | 1 | Acetaldehyde | 281.9 | 141.1 | 63.6 | 563.1 | μg/m^3 |
|                  |      |         | Regular        | 1 |        | 108.4 | 43.8 | 31.1 | 183.4 | μg/m^3 |
|                  |      |         | Total          | 1 |        | 229.9 | 144.2 | 51.1 | 563.1 | μg/m^3 |
| Author/Reference | Year | Country       | Type of Tobacco | N   | Type of Pollutants | Concentration | Unit       |
|-----------------|------|---------------|-----------------|-----|--------------------|---------------|------------|
| Rostami et al   | 2018 | Ardabil, Iran | Fruit flavored  | 701.1 | 334.3 | ng/m³         |
|                 |      |               | Regular         | 236.6 | 70.6   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 1192.4 | 257.2 | mg/m³         |
|                 |      |               | Fruit flavored  | 132.6 | 27.6   | mg/m³         |
|                 |      |               | Regular         | 95.4   | 32.9   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 136.4 | 21.6   | mg/m³         |
|                 |      |               | Fruit flavored  | 744.3 | 312.52 | mg/m³         |
|                 |      |               | Regular         | 328.7 | 83.9   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 1098.3 | 152.9 | mg/m³         |
|                 |      |               | Fruit flavored  | 849.4 | 202.28 | mg/m³         |
|                 |      |               | Regular         | 401.8 | 129.8 | mg/m³         |
|                 |      |               | Fruit flavored, regular | 950.3 | 115.7 | mg/m³         |
|                 |      |               | Fruit flavored  | 807.5 | 231.5 | mg/m³         |
|                 |      |               | Regular         | 360.6 | 100.4 | mg/m³         |
|                 |      |               | Fruit flavored, regular | 880.6 | 162.8 | mg/m³         |
|                 |      |               | Fruit flavored  | 754.8 | 341.3 | mg/m³         |
|                 |      |               | Regular         | 242.7 | 99.3   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 813.4 | 289.1 | mg/m³         |
|                 |      |               | Fruit flavored  | 219.3 | 75.7   | mg/m³         |
|                 |      |               | Regular         | 112.6 | 48.1   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 181.4 | 38.6   | mg/m³         |
|                 |      |               | Fruit flavored  | 384.4 | 161.7 | mg/m³         |
|                 |      |               | Regular         | 448   | 77.2   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 80.3 | 49.7   | mg/m³         |
|                 |      |               | Fruit flavored  | 42.9  | 11.3   | mg/m³         |
|                 |      |               | Regular         | 91.7   | 44.9   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 683 | 266.3 | mg/m³         |
|                 |      |               | Fruit flavored  | 250.4 | 68.4   | mg/m³         |
|                 |      |               | Regular         | 760.2 | 406.6 | mg/m³         |
|                 |      |               | Fruit flavored  | 110.3 | 44.9   | mg/m³         |
|                 |      |               | Regular         | 43     | 18.4   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 174.7 | 110   | mg/m³         |
|                 |      |               | Fruit flavored  | 299.9 | 108.8 | mg/m³         |
|                 |      |               | Regular         | 191.6 | 38.4   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 385.1 | 104.5 | mg/m³         |
|                 |      |               | Fruit flavored  | 172.1 | 99     | mg/m³         |
|                 |      |               | Regular         | 71.3   | 35.2   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 212.3 | 85.3   | mg/m³         |
|                 |      |               | Fruit flavored  | 20.3   | 5.1    | mg/m³         |
|                 |      |               | Regular         | 23.5   | 12.1   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 25.4 | 11.5   | mg/m³         |
|                 |      |               | Fruit flavored  | 38.9   | 17     | mg/m³         |
|                 |      |               | Regular         | 37     | 4.2    | mg/m³         |
|                 |      |               | Fruit flavored, regular | 75.6 | 22.8   | mg/m³         |
|                 |      |               | Fruit flavored  | 5915.2 | 650.5 | mg/m³         |
|                 |      |               | Regular         | 2404 | 271.4 | mg/m³         |
|                 |      |               | Fruit flavored, regular | 7304.9 | 846 | mg/m³         |
|                 |      |               | Fruit flavored  | 1435.3 | 83.9 | mg/m³         |
|                 |      |               | Regular         | 653.9 | 89.3   | mg/m³         |
|                 |      |               | Fruit flavored, regular | 1725.6 | 255.4 | mg/m³         |
|                 |      |               | Fruit flavored  | 779.5 | 169.8 | µg/m³       |
|                 |      |               | Regular         | 541.6 | 107.5 | µg/m³       |
|                 |      |               | Fruit flavored, regular | 694.4 | 255.1 | µg/m³       |
particles is higher than the annual guideline value. PM2.5 concentrations have been reported to be 1.3-449 times the guideline value. In the study by Heydari et al, the concentration of PM was significantly higher in the air inside the hookah cafe than in the air outside. Moreover, the concentration during weekend sessions was higher than during the weekday sessions. This is due to the presence of a large number of hookah users in cafes on weekends (4). Organic matter, sulfates, ammonium, nitrates, and different metals (e.g., copper, chromium, manganese, arsenic, lead, and zinc) are among the chemicals and components found in PM. According to the evidences, changes in PM2.5 levels in the air have been found to be linked to changes in the incidence of all-cause mortality and hospitalization, especially for cardiovascular and respiratory disorders (5). The high concentration of airborne particles inside hookah cafes has many risks for the health of hookah users. This risk is much higher for the staff working in the cafe who are present in these places all days of the week. In order to reduce the adverse effects of particulate matter released into the air inside the coffee house, it is necessary for the authorities to adopt and implement strict laws in this regard. The most important action in reducing the concentration of airborne particles in hookah cafes is to use a proper natural or artificial ventilation system.

In 1 study, the concentrations of bioaerosols (bacteria and fungi) were measured in 50 cafes. Due to the prevalence of COVID-19 and the assumption that waterpipe use is one of the possible routes of exposure to the virus of this disease, it is necessary to take strict measures to control bioaerosols in the indoor air of waterpipe cafes. Bioaerosol exposure can cause inflammation and irritation in the upper and lower respiratory tracts and allergic reactions in the lungs of those with asthma and chronic bronchitis (12). The main factors affecting the microbial levels
in the waterpipe café include indoor temperature and humidity, building age and size, the number of people using waterpipe, and lack of mechanical ventilation. Therefore, in order to reduce the microbial load in the air of hookah cafes, the focus should be on modifying the building, using a proper ventilation system, and reducing the number of people in each session of waterpipe use.

In two studies, the concentrations of BTEX compounds were measured. The results showed that the concentration of BTEX compounds in the indoor air of tobacco cafes is significantly high; therefore, it can pose a serious risk to the health of employees and customers. People who use fruit-flavored waterpipe are exposed to large amounts of these dangerous contaminants and therefore have a higher risk of cancer and non-cancer chronic diseases. In addition, cafes located in the basement, due to poor ventilation, accumulate large amounts of these pollutants and further endanger the health of customers. In addition, the risk assessment of exposure to BTEX compounds in the indoor air of cafes has shown that the carcinogenic and non-carcinogenic risks of these compounds exceed the safe limits recommended by the EPA. Therefore, more studies and monitoring should be done on these environments and appropriate control policies should be set for this public health threat (14, 16).

Aldehydes, specifically formaldehyde and acetaldehyde, are compounds that may be released during waterpipe smoking. Because of their negative health and carcinogenic effects, these compounds have been the subject of numerous toxicological studies. High levels of formaldehyde and acetaldehyde have been found to be linked to a variety of health effects in humans, including throat and eye irritation, asthma, increased sensitization, sick-building syndrome, an increased risk of adverse birth outcomes, bronchial asthma-like symptoms, headache, vomiting, eye irritation, nausea, and negative effects on skin and throat, as well as the respiratory tract (23). International Agency for Research on Cancer has classified formaldehyde as an intense human carcinogenic agent (group 1) and acetaldehyde as a possible human carcinogen (group 2B) (23). In two studies, the concentrations of formaldehyde and in one study, the concentrations of acetaldehyde in the indoor air of cafes were reported. The guideline value of formaldehyde for 8 hours of exposure in indoor environment has been determined to be 50 µg/m³ by Canada’s federal department of health (23). The concentration of formaldehyde in all the cafes was found to be higher than its guideline value. The main source of aldehydes in the environment of hookah cafes is burning coal and tobacco. Therefore, the most important solution to reduce these pollutants is to use traditional tobacco instead of artificial fruit flavored tobacco and, if possible, to decrease the burning temperature of tobacco.

In two studies, the concentration of PAH compounds was measured in waterpipe cafes. PAH can not only cause cancer-related mutagenic activity but may also have serious non-cancer consequences such as lung and cardiovascular diseases, lung failure, jaundice, and kidney and liver damage. Because of the high carcinogenic and non-carcinogenic risks that PAHs pose, appropriate health warning labels and restrictive measures regarding hookah smoking inside cafes should be used to reduce the associated health risks in this area. A significant increase in indoor air exchange rates is also necessary to reduce the PAH concentration to a safe and healthy level (24).

Identifying the source of p-PAHs remains a challenge, as they can result from many non-smoking sources, including car exhaust, cooking, spark plugs, and fumigation (22). Based on epidemiological data from studies on coke-oven workers, a unit risk for lung cancer for PAH compounds is estimated to be $5.8 \times 10^{-5}$ per ng/m³ of B(a)P. The corresponding concentrations for lifelong exposure to B(a)P producing excess lifetime cancer risks of 1/10000, 1/100000, and 1/1 000 000 are approximately 1.2, 0.12, and 0.012 ng/m³, respectively (27).

In 2 studies, the concentrations of lead, chromium, cadmium, nickel, iron, copper, zinc, aluminum, and uranium were measured. The results showed that those who smoke hookah with fruit-flavored tobacco are exposed to higher amounts of dangerous heavy metals. Therefore, these people have a higher risk of cancer and chronic non-cancer diseases. In addition, cafes in the basement accumulate more pollutants and therefore pose more serious risks to the health of customers due to the poor ventilation system or even its absence (15). The results also show that hookahs are the main sources of human release of heavy metals in waterpipe cafes and the number of active hookahs significantly affects the concentration of metals in the indoor air of waterpipe cafes. In this regard, limiting the number of hookahs in each shift of the cafe can effectively reduce the concentration of contaminants. Additionally, flavored tobacco, a popular tobacco type among young people, is a stronger source of the release of metals into the indoor air than traditional tobacco. Therefore, stricter regulations are needed to limit the use or production of this type of tobacco in order to reduce the health effects on smokers, café staff, and customers (25).

Conclusion

The results of the study show that the air in hookah cafes has several pollutants, most of which are harmful to health and can cause health problems such as respiratory disease, cardiovascular disease, and cancer. The concentration of most of these compounds is higher than the standard values recommended for them. Hookah use has grown significantly due to its higher social acceptance than cigarettes and also people’s misconception that hookah is less harmful than cigarettes among different age and gender groups, especially among adolescents and young people. In order to reduce hookah use, the following strategies are suggested: (a) informing people about the
adverse health effects of hookah use, (b) adopting and enforcing strict laws regarding hookah use, especially in public places and hookah houses, and (c) adequate monitoring of the quality of tobacco used.

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