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## The many faces of tobacco use among women

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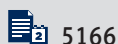
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Smoking is still considered to be mainly a male problem. However, it is estimated that there are approximately 250 million women worldwide who smoke cigarettes and millions more women who use smokeless tobacco products. This article addresses the many facets of tobacco use among women. The aim of the paper is to increase recognition among clinicians and researchers of the specific characteristics of female tobacco use. Together with providing epidemiological data on the distribution of tobacco use among women and data from population-based analyses on sociocultural factors that influence it, the article presents tobacco use during pregnancy as a particularly important public health problem. Further, the article points out sex-related differences (ie, physiological, psychological, or behavioral) between male and female tobacco use. A special focus is on the important role of ovarian hormones. Adverse effects of tobacco use to women and their children as well as tobacco-related morbidities and comorbidities are presented, and women's greater susceptibility to tobacco constituents as compared to men is stressed. Awareness of these differences can contribute to improvement of the effectiveness of smoking cessation programs addressed both to the specific female population and to an individual smoking woman.

**MeSH Keywords:** **Women • Pregnancy • Smoking • Tobacco Use Cessation**

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## Background

Since 1492, when Columbus discovered tobacco use among the inhabitants of Cuba, this habit has been spread and commonly accepted all over the world in a short time. Initially, because of socio-cultural reasons, tobacco was used generally by men as an activity that denoted their high social status. Beginning from 1840, when the Baroness de Dudevant, Frederic Chopin's mistress, first smoked tobacco in public, and together with changes in social views about women's smoking, women more commonly adopted that habit [1]. As the dangers of cigarette smoking were recognized, a remarkable decrease in smoking prevalence has occurred in major industrialized countries over the past half century. Although tobacco smoking is still primarily a habit and an addiction of men, it is estimated that at present nearly 250 million women in the world are daily smokers [2]. By the year 2025, because of a predicted rise in the female population from 3.1 to 4.2 billion, the number of smoking women will considerably increase, even if the prevalence of smoking in women remains unchanged [3]. Unfortunately, aggressive campaigns undertaken by tobacco the industry to recruit new smokers among girls and young women worldwide, as well as social changes observed in many developing countries, additionally enlarge the epidemic of cigarette smoking in females. Therefore, it is estimated that the number of female smokers might soon reach 532 million. It should be also kept in mind that woman worldwide use other, non-cigarette, tobacco products, which additionally increases the global burden of tobacco use.

This article addresses many facets of tobacco use among women. Its objective is to increase recognition among clinicians and researchers of the specific characteristics of female tobacco use, presenting these issues from an interdisciplinary perspective.

## Prevalence of Female Tobacco Use

### Epidemiology of cigarette smoking

The distribution of cigarette smoking among women varies from country to country. Available data collected in the 3<sup>rd</sup> edition of the WHO Tobacco Atlas indicate that in the majority of Asian, African, and Middle American countries, USA and Canada in North America, Brazil, Ecuador, and Paraguay South America, Australia, and the Russian Federation, as well as in several European countries, including Italy, Slovenia, Albania, and the Republic of Moldova, smoking women constitute no more than 20% of the adult female population [2]. However, in the majority of countries in Europe, the prevalence of smokers among women is 20–29.9%. For instance, in Portugal, Spain, Greece, Bosnia and Herzegovina, Hungary, Denmark, the Netherlands, and Norway the prevalence of female smoking

may reach 30–39.9%, and in Austria and Serbia it is 40–49.9%, which is the highest in the world [2]. It is noteworthy that currently in some countries, including Sweden and Iceland, more women smoke tobacco than men [2]. In general, in industrialized countries at present the rate of smoking women is on the average 22%, and in developing countries it is 9%, which surely reflects social traditions as well as women's scant economic resources [2]. Probably, low rates of female smokers in Asian and African countries may be higher than estimated because of under-reporting of this habit or lack of reliable data [4,5]. Recently, it was found in Korea that the rate of cotinine-verified smokers was 8% higher than the rate of self-reported smokers [4].

### Smokeless tobacco use

Cigarette smoking remains the most prevalent form of tobacco use in girls and in women globally. However, in many regions of the world, especially in low- and middle-income countries, a considerable proportion of women, including those of reproductive age, chew tobacco or use other tobacco products. For instance, in the central and southern part of India, 17–45% of women use mishri, which is a tobacco-containing teeth cleaning powder prepared by roasting tobacco leaves, and in Mumbai up to 56% of women chew tobacco in pan (betel leaf with areca nuts and aromatized tobacco leaves) [1,6]. Similarly, in Cambodia the prevalence of chewing tobacco among women more than doubles each decade of adulthood up to the point that about half of all older women chew tobacco [7]. In sub-Saharan Africa the use of pipes, snuff, and rolled tobacco leaves is believed to be widespread [8]. Another traditional method of tobacco use is water pipe smoking. This form of tobacco use is especially widespread in the Eastern Mediterranean region, where women and girls are more likely to take up water pipe smoking than to use other forms of tobacco, and it is popular among younger smokers [9]. Nowadays, water pipe smoking is gaining in popularity worldwide, including in developed countries such as the USA, where 10–20% of some young adult populations are current water pipe users [10].

## Factors Influencing Female Smoking

### Socio-cultural and socio-economic determinants of female smoking

In several major developed countries, such as the USA, Canada, UK, and Australia, women have considerably reduced their smoking, mainly as a result of promotion of healthy lifestyle and changes in women's attitudes towards smoking [2]. Smoking has now come to represent socioeconomic disadvantage because low socio-economic status (SES), determined mainly by the level of education and household income, is among the

strongest factors influencing smoking, both in men and women [11]. In addition, evidence indicates that in women, lower SES is correlated with greater exposure to tobacco smoke at home [11]. However, it remains unclear why women from poorer families are more vulnerable to active smoking [11]. Simultaneously, in some Western countries such as UK, Sweden, Austria, Denmark, Finland, and Germany, the increasing prevalence of smoking among adolescent females has occurred as a new phenomenon, and more girls than boys are now smoking in these countries [2]. In several other countries, female smoking has not shown any decline or is still increasing, for instance in countries of Southern, Eastern, and Central Europe [2]. Similarly, in several countries, where prevalence of smoking has traditionally been low, the current increase in smoking among women, particular in those who are well educated, is also noted. This trend may result from various factors, including socio-economic changes that affect societies of these countries. A weakness of social and cultural constraints that previously prevented many women from smoking is probably the most important factor encouraging women to smoke. It has been reported that in quickly developing India, female cigarette smoking exists mainly among the urban elite classes of large cosmopolitan cities, which may reflect the women's aspiration to "equal" the social position of men [12]. In China, a cross-sectional survey conducted in 2001–2002 has confirmed a low rate of current smokers in the general population of women (6.9%) in comparison to the male general population (60.2%) [13]. Cultural acceptance of smoking men in China probably contributes to the high smoking prevalence among them [4]. It may also help to explain the relatively high rate of smokers among male medical students (38%), while female medical students in China, where society traditionally stigmatize smoking women, especially those who are not married, do not smoke cigarettes at all [14]. Surprisingly, as it was recently reported, 20.3% of female physicians in China are smokers [15]. Earlier studies showed a 150% increase in the smoking prevalence among them during just 9 years as a result of dynamic economic development of this country, followed by social changes [16,17]. Taking into account the special profession of physicians, which should rather discourage women from smoking, the possible explanation for this phenomenon is that women in some countries desire to liberate themselves from the old culture.

### Advertisement

An important factor prompting women to begin and continue smoking cigarettes is aggressive promotion of cigarettes [18,19].

Advertisements addressed to women first appeared in USA in the 1920s. Tobacco advertising has used various means to attract women to cigarettes. The most important among these was the creation of a false image of smoking women and girls,

introducing them in mass media as emancipated, successful, sophisticated, glamorous, enjoyable, sexually attractive, romantic, and slim. That image for many years has been unchangeably linked to such themes associated with smoking cigarettes of particular brands. For example, nearly 100 special female brands, which appealed to the above image, have been distributed in the Russian Federation, where the prevalence of smoking among women is increasing rapidly [20]. The same means are now being applied in developing countries, and particularly target women with higher SES. As earlier in the USA for younger women, cigarette brands focus on female camaraderie, freedom, independence, and self-confidence, whereas cigarette brands for older women focus on social acceptability, pleasure, and relaxation from daily stresses [21].

The second important strategy of the tobacco industry is on production of specially formulated ("light", "slim", "super-slim", low-tar, light-coloured, or menthol) brands of cigarettes for women. Other marketing techniques addressed to women include brand-stretching (e.g. using cigarette names for clothing, travel, and bistros), internet promotions, sponsorship of cultural and sporting events, or free distribution of tobacco products.

### Psychological, behavioral, and psychosocial factors influencing female smoking

Numerous psychological, psychosocial, and behavioral factors influence female smoking as regards vulnerability to tobacco use, reasons for attempting to quit, or ability to maintain abstinence, and they often differ from factors influencing male smoking.

Psychological and behavioral determinants of female smoking include mode of smoking, negative affect and depression, fear of weight gain, environmental cues, need for social support in smoking cessation, and readiness and confidence in ability to quit [22,23]. Cigarette smoking behavior differs between woman and men. Women usually take smaller puffs of shorter duration, but draw more puffs per cigarette and leave longer butts [24]. Studies suggest that women and men perceive the function of smoking differently. Whereas men are more likely to report enjoyment and liking being a smoker as main motives to maintain smoking, women more often report stress relief and weight control as motives [23,25,26].

Smoking for weight control and concern about weight gain are emerging problems, especially for girls and young women, who may be more susceptible to media portrayals of idealized body image, like those presented in cigarette advertising. Many of them start smoking as a weight control strategy whereas others continue to smoke, even during pregnancy or after delivery to avoid post-cessation weight gain [27,28]. In developed countries the relationship between smoking and

weight concerns is particularly strong in adolescent and college age women [29–31].

Reasons for quitting smoking may also differ between men and women. It was found that women were about twice as likely as men to report feeling pressure to quit, and the source of this pressure was different than in men. Women reported pressure primarily from their children, whereas more men claimed pressure from friends and coworkers [32]. In Norway, female ex-smokers, compared to males, more frequently reported quitting smoking because of their children, in solidarity with a spouse who stopped smoking, and for cosmetic reasons such as skin problems. In turn, wanting to improve physical fitness was a more important reason to quit in men, especially younger men [33]. In several studies from other European countries men tended to be motivated to quit by medical advice, while women were motivated by a desire to be a good model for their children, to prevent diseases, or to improve their appearance [33,34]. The ability to maintain abstinence also differed in women and men. Although women attempted to quit cigarettes as frequently as men, they were less likely to abstain from smoking for at least 10 days [32].

One of the factors strongly associated with vulnerability to tobacco use, and studied broadly more recently, is childhood sexual abuse. In a French study, significantly more current smokers were noted among sexual abuse survivors compared to non-abused subjects. However, although the rate of smokers among young women (18–34 years) was similar to that of men in the same age range, women more frequently (up to five times more) reported a history of sexual abuse [36]. Smoking is suggested to be a coping strategy taken up by the victims of early childhood sexual abuse, and then continued because of endured nicotine dependence [35]. In a study conducted among women on a US college campus, those who were sexually abused in childhood were 3.8 times more likely than non-abused subjects to be current smokers and were over twice as likely to have started smoking before the age of 14. In fact, a history of being sexually abused as a child was a stronger predictor of smoking than age, ethnicity, or income [36]. In general, childhood sexual abuse seems to be one of the strongest factors influencing substance use disorders (cannabis, opioid, alcohol, or stimulant) in women and this, in turn, is strongly connected with heavier smoking, as well as smoking during pregnancy [37,38].

### **Tobacco Use and Quitting During Pregnancy**

Cigarette smoking or smokeless tobacco use among women during pregnancy is a problem that requires special attention because of their potential consequences for the health of mother and child, as presented later in this article.

### **The prevalence of smoking during pregnancy**

The prevalence of smoking during pregnancy varies markedly across countries and mirrors trends of smoking among all young women at all [39]. In many developed countries it is gradually declining, although several of these countries note an increasing prevalence of smoking among the youngest pregnant women [40]. In Denmark, for example, pregnancy-related smoking prevalence declined significantly, from 22% in 1997 to 16% in 2005. However, among women younger than 20 years at delivery, the rate of those smoking at any time during pregnancy increased from 37% to 43% [40]. In Canada, Australia, Germany, and Japan the overall prevalence of smoking during pregnancy does not exceed 20%, but it is nearly 22% in Spain and Italy, 26% in Poland, and 28% in France [41–48]. A nationwide population-representative survey in Serbia found 37% of women smoked at some point during pregnancy, and the rate was 2 to 3 times higher than in the most affluent Western countries [49]. In comparison, in Tunisia the smoking prevalence among pregnant women or mothers of newborn infants was 4% [50], but the validity of self-reported daily smoking was relatively low according to urinary cotinine values, which showed the pregnancy-related smoking prevalence was 18.8%, similar to that reported in another country of the same geographical and cultural region, Lebanon, where it was 20% [50,51].

### **Factors influencing smoking during pregnancy**

There is robust evidence that tobacco use among pregnant women is not affected by a single factor, but rather by a set of inter-related social-structural and psychosocial variables such as early or lone pregnancy, poor housing, low level of social support, negative interpersonal relationships, ineffective welfare policies, family structure, lower educational level, mood, introversion, low self-esteem, or history of abuse [11,52].

More recently, several reports have confirmed age, ethnicity, living in rural areas, multiparity, low SES, smoking by others in the home, family structure, social support, and antenatal care as factors influencing prenatal smoking [40–42,49,51,53–55]. For instance, in Australia the rate of smoking during pregnancy among all New South Wales women declined almost 2-fold from 22.3% in 1994 to 12.8% in 2007 [42]. Smoking was substantially higher among Aboriginal mothers compared to non-Aboriginal mothers, and the decrease rate among them was smaller – from 61.4% in 1994 to 50.2% in 2007 [42]. Higher smoking rate was linked not only to indigenous ancestry but also to teenage mothers. In turn, mothers born overseas, of higher SES, first time mothers, and those who attended antenatal care clinics in the first trimester were less likely to continue smoking during pregnancy [42,53].

Important determinants of smoking during pregnancy include psychosocial health attributes and other factors such as higher

levels of perceived stress, depression, anxiety, neuroticism, self-efficacy, and personality characteristics, as well as negative paternal support or perceived racism [54]. Studies also have shown an association between mental disorders and smoking during pregnancy and nicotine dependence among pregnant women. In a survey conducted in USA, 12% of women smoking during pregnancy met the criteria for nicotine dependence. Among all pregnant women smoking cigarettes, 45% of them met criteria for at least one mental disorder, including nicotine dependence [56].

### Smokeless tobacco use during pregnancy

Pregnant women worldwide also use other forms of tobacco, mainly in low income countries. In a study conducted among pregnant women in 9 developing countries, the rate of current users of smokeless tobacco products was 6% in Democratic Republic of Congo (chewing tobacco and/or snuss), and was 33.5% in Orissa, India (chewing tobacco and/or tobacco tooth powder) [57]. Consistently, in another report from India, 31% of pregnant women used *Mishri* [6]. In Beirut, nearly 7% of pregnant women smoke argileh, together with 20% of other Lebanese women who smoke cigarettes during pregnancy [51]. More recently, a literature review showed that 17% of women in Mumbai use smokeless tobacco products during pregnancy (80% of them use *Mishri*), 7% of pregnant women in Johannesburg, South-Africa and in Sweden use snuff, while in the Alaska Native community of Canada, 50% chew tobacco [58].

There is growing, although still sparse, evidence that suggests an association between the use of some non-cigarette tobacco products during pregnancy and the increased risk of perinatal complications consistent with that found in pregnant women smoking cigarettes [7,59]. Women users of *Mishri* had 2.7 times greater risk of abnormal delivery than non-users. Moreover, the birth weight was significantly lower compared to women who never used *Mishri* [7]. Similarly, water pipe smoking and use of snuff were found to be strongly associated with lower birth-weight [59,60]. Swedish pregnant women who were snuff users had increased risk of stillbirth, comparable to women who smoked 10 or more cigarettes daily during pregnancy, and had increased risk of preeclampsia compared with non-users [60,61].

### Quitting during pregnancy

Many women attempt to quit tobacco during pregnancy, being motivated mainly by concern about the health of their unborn babies and themselves, as well as by a set of extrinsic factors, including physiological changes in taste and smell of smoke during pregnancy [62]. However, cessation attempts are often unsuccessful and the rate of pregnant smokers who

succeed in quitting smoking is no higher than approximately 30% in Western countries [63]. Despite being fully aware of tobacco's hazards, women smoking during pregnancy tend to minimize the tobacco-related risk for their babies and themselves [64]. Skepticism about fetal smoking-related harm is one of the identified barriers to quitting, which include intrinsic factors (e.g. role and meaning of smoking, short-term thinking of quitting only for pregnancy, lack of willpower, fear of weight gain, negative view of cessation service provision, as well as physical and psychological addiction), and extrinsic factors (e.g. changes in a couple's interactions during pregnancy, or family and friends smoking) [65]. In addition, most women who successfully quit smoking during pregnancy relapsed during the first 6 months postpartum. Having a partner and friends who smoked was the most important reason for relapse [66]. Changes in mood, concerns about weight and perceived stress, and sleep deprivation other most important barriers to maintaining smoking abstinence in the postpartum period [27,54,67,68].

To assist pregnant women in quitting smoking, application of nicotine, the psychoactive constituent of tobacco, responsible for addiction, has been attempted. This approach is consistent with the harm reduction philosophy [69]. However, the risk-benefit ratio of nicotine replacement therapy (NRT) in pregnancy remains unclear. Recently released US guidelines state the need for further studies, and recommended providing appropriate counseling for pregnant women who smoke [70].

### Nicotine Dependence in Women: Biological Basis

To better understand the complexity of female tobacco, one must consider the differences between women and men in tobacco dependence and its biological background.

Recent evidence indicates differences between men and women in patterns of cigarette smoking, biological response to nicotine, progression to dependence, the nicotine cue reactivity in the phase of maintaining abstinence, smoking treatment effectiveness, and health consequences of tobacco smoking. Data from laboratory animal studies, including those on acquisition phase of nicotine addiction, suggest that females may be more sensitive than males to the reinforcing effect of nicotine, and females are more motivated to self-administer nicotine [71–73].

There is also evidence that the progression to nicotine dependence differs between women and men. Women need a shorter time period of tobacco use compared to men to progress to nicotine dependence. However, the degree of dependence is similar in males and females [74].



Several studies suggested that quitting smoking may be more difficult for women than men [75–80]. Women tend to relapse faster, and experienced difficulties in sustaining abstinence, especially in the initial stages of smoking cessation within the first 1–2 days [75–78]. Generally, women had less frequent or shorter abstinence periods in comparison to men [79,80].

Both animals and human studies on transition from a period of nicotine abstinence to resumption of regular tobacco use demonstrated that relapse can be triggered by both internal (e.g. priming dose of nicotine) and external (e.g. tobacco-associated accessories or places) stimuli. Clinical data suggest that women differ from men in their response to nicotine cues. While in men internal cues are more important in modulating maintenance or relapse to smoking, external nicotine cues are more important for women, probably due to their greater subjective and reinforcing effects in women [81]. In other words, nicotine influences female smoking behaviour less prominently than in males. Several studies provided evidence that women are more likely to relapse due to a stressful event or to depression that lowers self-efficacy about maintaining nicotine abstinence [22,82]. Depression, anxiety, and low self-esteem are considered the most common risk factors associated with relapse to nicotine and other drug use after treatment in women [83]. Other important factors include lower confidence in ability to quit and greater concern about gaining weight after quitting [84–86].

Reports on effectiveness of nicotine replacement therapy in women are inconsistent. Some authors found that in women it is less suppressive on some nicotine withdrawal responses compared to men, resulting in lower efficacy in nicotine dependence treatment [87,88]. Other studies did not confirm any gender differences in the outcome of smoking treatment [89].

### The influence of female hormones on smoking behavior

A recent subject of interest is whether physiological changes in the level of sex steroid hormones during various phases of the menstrual cycle influence smoking behavior. In spite of conflicting data, findings reported in the literature suggest that fluctuation in estradiol and progesterone levels may play a role [90]. Some studies indicated that the luteal phase fostered smoking: intake of nicotine was greater in that phase in comparison to the follicular phase, there was greater desire to smoke and to relieve negative affect, and cue-craving was more pronounced [91–95]. Other studies have suggested that nicotine intake was elevated in the menses phase of the cycle, whereas several other studies did not report any phase effect [96–99]. As regards the influence of female hormones on quitting smoking, various studies have suggested potential differences in withdrawal symptomatology and craving, depending

on menstrual cycle phase [92,93,95,99–101]. In addition, progesterone treatment in the early follicular phase was found to attenuate the craving for cigarettes and subjective effects from smoking. Females treated with progesterone were more likely to decrease smoking [102]. This finding suggested an enhanced effect of estrogen in the follicular phase in comparison to more attenuated effect of progesterone in the luteal phase, which might be responsible for lower quitting success rate in the group of follicular phase quitters. More recently, it was reported that women attempting to quit in the follicular phase had less favorable outcomes than those attempting to quit in the luteal phase [90]. Despite lack of consistency, growing evidence indicates that female success in quitting attempts might be influenced by phase-related differences in the severity of withdrawal symptomatology, which plays a role in early relapses [103,104].

Women may also have altered nicotine metabolism compared to men, due to influence of ovarian hormones, which in turn may have an impact on the outcome of smoking cessation attempts. There is evidence that estrogen may enhance nicotine metabolism in women, and thereby affect nicotine dependence and ability to achieve success in quitting smoking [105,106]. It was also found that in women taking oral contraceptives composed of estrogen only or combination of estrogen and progesterone, as well as in pregnant women, the turnover of nicotine was accelerated in comparison to women who were not taking contraceptives or who were not pregnant [105,106]. Because of alterations in nicotine pharmacokinetics mediated by estrogens acting as non-competitive nicotinic receptor antagonists, nicotine replacement therapy seems to be less effective in smoking women [107]. In summary, the literature indicates an important role of ovarian hormones in nicotine dependence and supports a general consensus that women experience more difficulties in smoking cessation.

### Hazards of Tobacco Use for Women and Their Children's Health

Tobacco use and exposure to smoke are serious threats to the health of women and their children, as widely reviewed elsewhere [108,109]. Smoking currently causes approximately 0.5 million premature deaths among women in developed countries and 0.3 million in developing countries each year [110]. It is estimated from 2013 to 2030 more than 20 million women will die from the consequences of tobacco use [111].

Cancer (particularly lung cancer), cardiovascular diseases, COPD, and other tobacco-related disorders occur significantly more frequently in women who smoke. In addition to these health risks that typically also affect men, they face particular tobacco-related problems as women, including higher incidence of cancer of the

cervix, irregular menstrual cycles, higher incidence of dysmenorrhoea, as well as coronary disease risk when using oral contraceptives and increased risk of infertility [110]. Tobacco use by women during pregnancy exerts a great toll on the mother and fetus at all stages of prenatal development, at birth, in infancy and childhood, in adolescence, and throughout adult life. This is a major public health problem, and effective antismoking interventions could reduce the obstetric and perinatal complications of it, as well as protect future generations from disease. Growing evidence indicates that smoking during pregnancy is associated with a higher incidence of obstetric and perinatal complications, such as ectopic pregnancy, spontaneous abortion, preterm birth, placental abruption, fetal growth restriction, and possibly also sudden infant death syndrome [109,112,113]. Evidence also exists on the lasting adverse effects of smoking during pregnancy on children. It may increase the risk of pediatric asthma, bronchitis and wheezing illness, childhood obesity, elevated blood pressure in children, diabetes, and neurobehavioral disorders in childhood and adolescence, including behavioral problems, hyperactivity, learning disabilities, attention deficit disorders, and increased probability of smoking later in life [109,114,115]. Recently, it has been reported that even heavy smoking before pregnancy, in spite of quitting before becoming pregnant, had a negative impact on children's future cognitive abilities [116]. As regards women beyond reproductive age, women smokers experience earlier occurrence of menopause, with an increased incidence of hot flashes and increased risk of heart disease and osteoporosis [108]. In postmenopausal women, cigarette smoking deteriorates the clinical picture of chronic diseases (e.g. arterial hypertension) and encourages development or progression of atherosclerosis, partially because of a possible greater contribution of the postmenopausal deficit of dehydroepiandrosterone sulfate (DHEA-S) to this pathology in women smokers than in nonsmokers [117].

Smokeless tobacco products contain nicotine and many carcinogens and other toxins hazardous to health. They may cause cancers of the oral cavity, oesophagus, and pancreas [118]. Unfortunately, non-cigarette tobacco products are commonly considered to be less harmful or even harmless in comparison to smoking cigarettes. Some women believe that water pipe tobacco smoking is harmless, but a recent systematic review of studies on this habit and its harmful effects showed significant associations with lung cancer, respiratory illness, and periodontal disease [59].

### **Gender differences in susceptibility to smoking-related problems**

Several studies suggest that female smokers may be more susceptible than men to harmful effect of carcinogens in tobacco smoke [119]. Recently, in concordance to these reports, reduced levels of global DNA methylation, which were associated with

genomic instability and the risk of cancer, were found more frequently in women compared to men [120]. Several other studies, however, have not confirmed the differences in risk of lung cancer between men and woman [121,122]. Epidemiological data suggest that female smokers may have greater susceptibility than males to develop COPD [123–125]. The biological mechanisms for this difference remain poorly understood. Nevertheless, other mechanisms may exist, such as a greater accumulation of tobacco smoke-derived toxins in female lungs, impaired clearance of these xenobiotics, and disturbance in the balance between conversion to more toxic metabolites or detoxifying them as a result of up-regulation by estrogen certain cytochrome P450 enzymes [126].

A survey of the literature on tobacco-related vascular diseases showed that nicotine addiction causes unique deleterious effects in women's brains by inhibiting estrogen signaling, which makes the brain more susceptible to ischemic damage [127]. A recent systematic review and meta-analysis of prospective cohort studies did not definitely determine whether mechanisms underlying the sex difference in risk of coronary heart disease are biological or related to differences in smoking behavior between men and women [128].

### **Conclusions**

Tobacco use among women has many faces in the contemporary world, and is the subject of interest of many scientific disciplines, most of all public health. The main form of tobacco use is still smoking cigarettes. However, smokeless tobacco use, which is common in some developing regions of the world, is now becoming more popular among women in industrialized countries. Although in many developed countries the overall prevalence of smoking among women has decreased considerably, this trend has not affected women who are disadvantaged. On the contrary, in developing countries women with higher socioeconomic status are smoking more. Another major problem is the growing prevalence of smoking among girls and young women. Among factors responsible for this increase is their concern about weight and considering smoking a good method to weight control. Active or passive smoking is responsible for a number of health problems for women, and, in case of pregnant women, for the unborn child as well. Women are more vulnerable than men to nicotine dependence and experience greater difficulties in smoking cessation, which is due to both physiological and psychological factors. Women are also more vulnerable to the harmful effects of tobacco smoke constituents in comparison to men, which causes women to be at greater risk of smoking-related diseases.

All these factors define the new challenges for global comprehensive anti-tobacco campaigns addressed to women. Such

campaigns should focus on decreasing tobacco use in specific sub-populations, such as schoolgirls, young pregnant and mothering women, and women with lower SES, and increasing effort against expansion of tobacco companies in developing countries, which are often aimed at women. The improvement of tobacco control initiatives might be achieved with the broader consideration of sex (ie, biological characteristics of women), gender (ie, social-structural and psychosocial characteristics of women: personality traits, attitudes, values, and gender roles played in society) and diversity (e.g. race, ethnicity,

socioeconomic status) factors, together with their interaction with cultural and temporal factors that contribute to vulnerability of women and girls to tobacco use and smoke exposure.

The abbreviations used are: SES, socioeconomic status; NRT, nicotine replacement therapy

### Competing interests

The authors declare that they have no competing interest.

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