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TOBACCO & VISION LOSS

What is vision loss?

Vision is one of the most dominant of the five physical senses and plays a crucial role in every area of our lives. Vision impairment is a major public health issue across the globe. Currently, around 2.2 billion people worldwide have a vision impairment. Of those, 1 billion have a vision impairment that could have been prevented or one that has yet to be effectively addressed (*1*). The International Classification of Diseases, Eleventh Revision, classifies blindness as presenting with visual acuity worse than 3/60 in the better eye (*2*).[1] The 2019 *World report on vision* defines mild, moderate and severe vision impairment as presenting visual acuity worse than 6/12, 6/18 and 6/60, respectively.

The majority of blindness and vision impairment is due to noncommunicable eye diseases, such as cataract, diabetic retinopathy, glaucoma and macular degeneration. Early detection and management of eye health conditions can prevent or minimize vision impairment and blindness and any associated social, well-being and financial burden on the individual and community (*2*).

Tobacco use is a risk factor for the development of vision impairment and blindness. This tobacco knowledge summary will address tobacco use as it relates to the following conditions.

- **Cataracts:** Cataracts are generally characterized by cloudiness in the lens of the eye, leading to increasingly blurred vision over time. Symptoms usually include gradual loss of vision or blurry vision, sensitivity to light, impaired night vision and seeing ghost images. As the leading cause of vision loss in the elderly, affecting 65.2 million people globally, cataracts also contribute to falls and poorer quality of life (*2*). As cataracts grow, these symptoms tend to worsen, especially with age (*3, 4*). Most cataracts develop with ageing, but the risk of developing the condition can be influenced by several factors, such as diabetes, tobacco use and use of topical steroids.
- **Glaucoma:** Glaucoma is a group of diseases or conditions that leads to progressive damage to the optic nerve, causing gradual vision loss. Globally, 76 million people are estimated to have glaucoma, 6.9 million of whom have moderate or severe distance vision impairment or blindness caused by glaucoma (*2*). Initially, loss of vision occurs in a person's peripheral vision, which can progress to tunnel vision, a severe reduction of peripheral vision. Dry eye is a common condition for people diagnosed with glaucoma, and tobacco use could increase the risk of developing glaucoma and dry eye compared with those who have never smoked.
- **Macular degeneration:** Macular degeneration, or age-related macular degeneration (AMD), is a common eye disease, occurring particularly in older people, that can severely and irreversibly impact the person's central vision (*5*). Globally, it is estimated that 196 million people have AMD and

1 "Distance visual acuity is commonly assessed using a vision chart at a fixed distance (commonly 6 metres (or 20 feet) […] For example, a visual acuity of 6/18 means that, at 6 metres from the vision chart, a person can read a letter that someone with normal vision would be able to see at 18 metres. 'Normal' vision is taken to be 6/6." (*2*).

Definitions

Smoked tobacco product: any product made or derived from tobacco which generates smoke. Examples include manufactured cigarettes, roll-your-own tobacco, cigars, shisha (also known as waterpipe), kreteks and bidis.

Second-hand smoke (SHS): the combination of "mainstream" smoke exhaled by the smoker and "side-stream" smoke emitted into the environment from the burning end of a cigarette or from other smoked tobacco products, usually in combination with the smoke exhaled by the smoker (International Agency for Research on Cancer, 2012). The terms "passive smoking" or "involuntary smoking" are also often used to describe exposure to SHS.

Smokeless tobacco: any product that consists of cut, ground, powdered or other that is intended to be placed in the oral or nasal cavity. Examples include snuff, chewing tobacco, gutka, mishri and snus.

Electronic nicotine delivery system (ENDS) (more commonly known as e-cigarettes): any battery-operated device that heats a solution, or e-liquid, to generate an aerosolized mixture containing flavoured liquids and nicotine that is inhaled by the user.

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that 10.4 million of these suffer from moderate or severe distance vision impairment or blindness from more severe forms of the condition (*2*). AMD is characterized by damage to the macula or central part of the retina responsible for detailed vision, which leads the person to see dark patches or shadows or lose their central vision. AMD affects people's ability to read, drive a car, recognize faces and colours and see objects in fine detail (*6*). Tobacco smoking is the primary modifiable risk factor for AMD; tobacco users may have a twofold-to-fourfold increase in risk of developing the condition compared with never smokers (*7*).

The problem

Prevalence

Eye conditions are remarkably common, but exact estimates of the global magnitude of the issue are lacking. The 2019 *World report on vision* (*2*) suggests that, globally, 2.2 billion people have a vision impairment, of whom at least 1 billion of these cases could have been prevented or has yet to be addressed. The 2.2 billion figure takes into account those with near-vision impairment due to presbyopia (1.8 billion) and moderate-to-severe distance vision impairment or blindness due to unaddressed refractive error, e.g. myopia or hypermetropia (123.7 million), cataract (65.2 million), AMD (10.4 million), glaucoma (6.9 million), corneal opacities (4.2 million), diabetic retinopathy (3.0 million), trachoma (2.0 million) and other causes (37.1 million).

Vision loss increases the risk of premature mortality – and this risk increases as vision loss becomes more severe. The risk of premature mortality is 29% higher for people with vision loss that is mild or worse, 49% higher for people with vision loss that is moderate to severe or worse, and 157% higher for people with blindness (*8*).

The distribution of the burden of most eye conditions and vision impairment is not equitable. Notably, 90% of people living with vision loss are in low- and middle-income countries. South Asia and Sub-Saharan Africa experience the highest rates of vision loss. Inequalities within regions, countries and communities also exist, but are often masked by national averages (*9*). The use of eye care services is uneven, and is often influenced by multiple factors, including the availability, affordability, accessibility and acceptability of services (*2*).

Impact

The burden of vision loss has become increasingly debilitating and impacts the quality of life of the people affected around the world (*10*). The Global Burden of Disease Study 2017 (GBD) ranked vision impairment, including blindness, as the third cause among all impairments for years lived with disability. Reduced vision capacity can also negatively impact involvement in education, social activities, fulfilment of daily tasks starting from a young age, participation in the workplace and ability to manage other health conditions later in life. Evidence shows that improving eye health is a practical and cost-effective way of unlocking human capital (*11*).

In the 2004 Surgeon General's report, it was noted that blindness was the second most feared disability in the United States of America, exceeded only by mental incapacity (*12*). Part of this is due to the fact that eye diseases can have a number of detrimental social and economic impacts. Vision impairment also poses an enormous global financial burden due to productivity and opportunity loss, in addition to costly procedures to manage vision loss (*13*). Vision loss accounts for US$ 410.7 billion in lost productivity annually (*13*), and US$ 134 billion per year in the United States alone (*13*).

Pathophysiology of tobacco use in vision loss

There is no safe level of exposure to tobacco, which kills more than 8 million people every year. Over 1.2 million of these deaths are due to exposure to second-hand tobacco smoke (*14*). Nicotine contained in tobacco is highly addictive, and tobacco use is a major risk factor for cardiovascular and respiratory diseases and over 20 different types or subtypes of cancer. Many other debilitating health conditions are related to tobacco use, including vision loss.

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With a single breath, the hundreds of toxins in tobacco smoke begin damaging the lungs (*15*). These toxins then pass from the lungs to the bloodstream and to various organs throughout the body, including the eyes (*15*). In addition to the impact of tobacco smoking on the development of eye disease in the user, tobacco smoke irritates the eyes and worsens dry eye syndrome in smokers and bystanders exposed to second-hand smoke, particularly among those who wear contact lenses (*16*).

Tobacco smoking and vision loss

Age-related macular degeneration (AMD)

Smoking is the primary modifiable risk factor for the development and progression of AMD (*6, 8, 17*). Tobacco smoking generates a local inflammatory response, and cigarette smoke is a strong oxidant. Furthermore, oxidative stress was found to be one of the primary mechanisms for smoking-related damage to retinal structures, contributing to the development and progression of AMD (*17*).

Evidence from a meta-analysis including 17 large studies was reviewed to assess the relationship between tobacco smoking and AMD (*6*). The studies in the meta-analysis varied between cross-sectional, prospective cohort and case–control. Thirteen of the studies revealed a statistically significant relationship between smoking and AMD. Current smokers and past smokers were at an increased risk of developing AMD, as compared with never smokers (*6*). The analysis found a fourfold increase in risk for neovascular AMD and a twofold-to-threefold increase in the risk of atrophic AMD associated with smoking (*18*).

The 2014 United States Surgeon General's report on the health consequences of smoking reviewed case–control, cross-sectional and prospective cohort studies in a meta-analysis to understand the relationship between smoking and AMD. Of these three different types of studies, information from the cohort studies appeared to be the most informative. A comprehensive analysis demonstrated that there was a strong association between both current smokers and past smokers and the development of AMD.

A study published in 2008 noted that AMD can have debilitating effects because of the degeneration it causes in the central part of the retina; this area is essential for tasks such as driving and reading. Peripheral vision generally remains unaffected, but it is usually inadequate for many tasks of daily living and prevents those affected from driving (*19*).

Other research conducted in France, the Netherlands and Singapore, summarized in the 2014 Surgeon General's report, revealed a dose–response relationship between pack-years of smoking and AMD (*17*). One large cohort study among males in the Republic of Korea found the duration of smoking and daily cigarette consumption to have a dose-dependent association with the incidence of neovascular AMD (*20*).

Smokers also have a greater risk of developing AMD at a younger age (*18*). A study conducted in 2019 found that current smokers developed AMD 5.5 years earlier than never smokers, and 4.4 years earlier than ex-smokers (*21*).

Cataract

There are several different types of cataracts, each with their own distinct risk factors, and tobacco smoking plays a part in the development of nuclear cataract, the most common type (*18, 22, 23*). Studies have shown that smoking appears to generate free radicals, which raises the oxidative stress in the lens of the eye. This lowers the concentration of plasma in antioxidants, inhibiting their ability to discard damaged proteins. Cataracts develop when these proteins build up in the lens causing vision loss, and surgical removal of the cloudy lens and replacement with an artificial lens is the only option to restore vision (*4, 22, 24, 25*). Tobacco smoking also affects the risks for cataract surgery and outcomes (*26*).

One prospective cohort study (in 44 000 men) found an association between smoking intensity and cumulative dose of smoking and an increased risk of requiring cataract surgery. Current smokers of more than 15 cigarettes per day had a 42% increased risk of undergoing cataract extraction (rate ratio, 1.42; 95% confidence interval (CI) 1.28–1.58) as compared with never smokers (*24*).

The United States Surgeon General's 2004 report on the health consequences of smoking (*13*) reveals that smoking may be associated with increased risk of posterior subcapsular cataract, but this potential relationship requires further investigation.

Glaucoma

New evidence suggests that smoking may increase the incidence of glaucoma (*27*). One study followed a cohort of smokers for 8.5 years, recording their smoking habits and recording the incidence of glaucoma. After controlling for potential confounders, current smokers were found to be at increased risk of developing glaucoma as compared with never smokers (hazard ratio 1.88, p=0.002, 95% CI 1.26–2.81). Further, the same study found a dose–response relationship between the number of cigarette pack-years and glaucoma incidence. Former smokers, as well as non-smokers exposed to second-hand smoke, were not found to be at an elevated risk of glaucoma. Few studies have examined the relationship between tobacco and glaucoma in depth, indicating the need for further research before conclusions can be drawn (*27*).

Smokeless tobacco and vision loss

There are limited studies on the ways in which smokeless tobacco impacts vision. A study conducted in Chennai, India in 2001 assessed glaucoma development in rural Indian people. Of the people among the study population who smoked, over half (52.8%) responded that they also used tobacco in its smokeless form. The odds ratio (OR) for history of tobacco use in any form and cataract was 1.39 (95% CI 1.15–1.68), when adjusted for age and sex. Smokeless tobacco use was found to be statistically associated with nuclear cataract (OR 1.67, p=0.067, 95% CI 1.16–2.39) after adjusting for age and sex (*28*).

Second-hand smoke and vision loss

A study conducted at the University of Cambridge and University College London, United Kingdom demonstrated that individuals who live with a smoker for at least five years are twice as likely to develop AMD as those who do not. Regular smokers, defined by the study as those who smoked at least one pack a day for 40 years, were three times more likely to develop AMD later in life (*23*). Another study suggests that ambient exposure to tobacco smoke in the environment can play a significant role in the likelihood of developing eye disease and can impact treatment outcomes (*19*).

A study conducted at the Chinese University of Hong Kong Eye Centre in 2019 examined the impact of second-hand smoke on a cohort of children between 6 and 8 years old, a third of whom had been exposed to second-hand smoke. Scientists measured the thickness of the choroid, which is the part of the eye that thins when exposed to tobacco smoke, and found that children who had been exposed to second-hand smoke experienced choroidal thinning of between 6 µm and 8 µm. This thinning can slow or completely stop choroidal blood flow, which leads to future vision loss associated with macular degeneration. The study revealed a dose–response relationship, with children experiencing a greater risk of choroidal thinning if more family members smoked (*29*).

Studies have shown that babies whose mothers smoked while pregnant are five times more likely to develop bacterial meningitis, which can cause vision problems as a result of the swelling of tissues around the brain (*30*).

E-cigarettes and vision loss

Evidence of a potential relationship between e-cigarette use and visual impairment is evolving. A recent population survey study conducted in the United States revealed that current e-cigarette users were at higher odds of visual impairment as compared with never e-cigarette users, independent of traditional cigarette use (*31*).

A review of the impact of e-cigarette use on ocular health (*32*) reported incidents of dry eye after e-cigarette use, as a result of disturbance in tear film stability. Dry eye is exacerbated by the voltage

of the e-cigarette device during use, as higher voltage led to further aggravation of symptoms. This is mainly due to the increased concentration and release of toxins in the e-liquid, namely free radicals and aldehydes, at higher temperatures. Notably, flavours containing ethyl maltol and linalool may increase the production of free radicals which are harmful to the eyes. Minor traces of bilateral corneal staining have also been identified in e-cigarette users, as well as a decrease in ocular blood flow, altered retinal function and increased risk of developing eye cancer. Further, several studies have shown adverse events after e-cigarette use, such as dizziness, nausea, blurred vision and loss of vision requiring surgery (*32, 33, 34*). In addition, there have been incidents where the e-cigarette device exploded in the consumer's mouth (*33*), causing chemical burns, decreased visual acuity along with long-term ocular trauma, such as severe corneal lacerations, and ocular tissue damage caused by foreign bodies and flying debris (*32, 33*).

Tobacco cessation

While the risk of neovascular AMD is higher among former and current smokers as compared with never smokers, the risk is more pronounced among current smokers than former smokers. One meta-analysis found evidence of reversibility of the effects of smoking, with ex-smokers having a lower risk of AMD compared with current smokers (*6*), but the 2014 report of the United States Surgeon General states that the evidence is suggestive, but not sufficient to infer that smoking cessation reduced the risk of AMD. Individuals who quit tobacco smoking for at least 20 years reduce their risk of developing AMD to that of a non-smoker (*17*).

Smoking cessation may also decrease the risk of needing cataract surgery. However, after 20 years of cessation, evidence suggests that men who smoked 15 or more cigarettes per day had only a 21% increased risk of requiring cataract extraction (*24*).

Tobacco cessation also lowers the risk of other diseases, such as cardiovascular disease and diabetes mellitus, which can lead to vision loss.

Next steps for prevention

Population-level action

As tobacco-related vision loss places a significant health and socioeconomic burden on individuals, families and communities, strategies such as reducing the demand for tobacco and exposure to second-hand smoke, as well as helping tobacco users to quit, are key areas of action. Preventing the uptake of tobacco use and encouraging tobacco users to quit is critical in reducing the burden of tobacco-related eye conditions. Tobacco control advocacy campaigns should increase messaging around the risk of tobacco smoking and vision loss, as well as the risk of using novel and emerging nicotine and tobacco products.

In addition to the harmful toxins in e-cigarette and e–liquids, there is increasing concern about newer products, which may be adulterated and not well regulated, leading to explosions during use. Individuals who use these products tend to be younger, which exposes them to eye injury early in life. Proper education about these risks may help users to make more informed choices and raise awareness around ocular health more broadly (*32*). It may also encourage cessation of the use of e-cigarettes and similar products.

To reduce the demand for tobacco, governments are strongly encouraged to implement the measures laid out in the WHO Framework Convention on Tobacco Control (*35*), with a particular focus on the MPOWER measures for demand reduction (*36*). Raising taxes on tobacco products and banning the advertisement, promotion and sponsorship of tobacco products are critical to reducing the demand for tobacco. Given the effectiveness of smoke-free environments in protecting people from the harms of exposure to second-hand tobacco smoke, governments should continue to implement measures to create, promote and enforce smoke-free environments. This effort should include warning the general public about the harms of tobacco use through graphic health warnings on tobacco packs and mass-media campaigns, and ensuring the availability of tobacco-cessation services, including tobacco quitlines and integration

of brief advice for tobacco cessation into the health system at all levels. Plain packaging on tobacco products is another effective strategy to reduce the demand for tobacco. To increase access to eye care services for early detection and management of eye care issues related to tobacco smoking, governments are strongly encouraged to implement the measures laid out in the WHO guide for action for integrated people-centred eye care (*37*).

Individual-level action

Quit smoking: The benefits of quitting are almost immediate. Within just two weeks of quitting, circulation improves and lung function increases. Quitting tobacco improves the health of many vital systems, such as the cardiovascular and respiratory systems, which also significantly reduces the risk of AMD development. Individuals who quit tobacco smoking for at least 20 years reduce their risk of developing AMD to that of a non-smoker (*17*). Given that there is no known treatment for macular degeneration, prevention strategies at an individual level are crucial.

Eliminate exposure to second-hand smoke: As with macular degeneration, tobacco cessation and reducing exposure to second-hand smoke are essential to prevent the development of cataracts, glaucoma and other serious eye diseases.

Keep the home and work environment completely tobacco-free: Those who use tobacco should be encouraged to quit and to only use tobacco outside, far away from the indoor environment of a house or office.

Maintain your general health: Further, to help prevent smoking-related AMD, it is important to maintain a healthy weight and stay physically active. The consumption of fresh fruits and green leafy vegetables, which are high in antioxidants, can help prevent the development of AMD (*11, 38*). Regular exercise and a healthy diet including dark, leafy greens are important in the prevention of cataracts. Since ultraviolet light exposure is a known risk factor, wearing proper sun protection, such as sunglasses and hats, can also help delay the onset of cataracts and other eye diseases (*4, 39*).

Have regular eye tests to detect eye problems early to prevent or minimize vision loss. Eye tests are particularly important to detect AMD, diabetic retinopathy and glaucoma and to ensure timely cataract surgery.

Methods

WHO conducted a comprehensive literature search for systematic reviews and other articles investigating the relationship between tobacco use, exposure to second-hand smoke and vision impairment, as well as a review of literature on e-cigarette use and its possible association with ocular health. Inclusion criteria included human study population, vision impairment and tobacco use (both smoking and smokeless) or exposure (second-hand smoke or environmental tobacco smoke) at any time over the life course. The review was not limited to any particular study design or language; however, the literature review identified very few studies in languages other than English.

Further information

For further information, see the WHO webpages on tobacco (*40*) and the MPOWER demand reduction measures (*36*).

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