REVIEW ARTICLE

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The Epidemiology of Smoking
Health Consequences and Benefits of Cessation

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Abstract

Tobacco use is the single most important preventable health risk in the developed world, and an important cause of premature death worldwide. Smoking causes a wide range of diseases, including many types of cancer, chronic obstructive pulmonary disease, coronary heart disease, stroke, peripheral vascular disease, and peptic ulcer disease. In addition, smoking during pregnancy adversely affects fetal and neonatal growth and development. Recent decades have seen a massive expansion in tobacco use in the developing world and accelerating growth in smoking among women in the developed world. Globally, smoking-related mortality is set to rise from 3 million annually (1995 estimate) to 10 million annually by 2030, with 70% of these deaths occurring in developing countries.

Many of the adverse health effects of smoking are reversible, and smoking cessation treatments represent some of the most cost effective of all healthcare interventions. Although the greatest benefit accrues from ceasing smoking when young, even quitting in middle age avoids much of the excess healthcare risk associated with smoking. In order to improve smoking cessation rates, effective behavioural and pharmacological treatments, coupled with professional counselling and advice, are required. Since smoking duration is the principal risk factor for smoking-related morbidity, the treatment goal should be early cessation and prevention of relapse.

According to World Health Organization (WHO) estimates, there are currently 1.1 billion tobacco smokers worldwide, representing about one-third of the entire population aged 15 years and over (table I).[1] The majority of these smokers are found in developing countries (800 million) and most are male (700 million). Globally, it is estimated that some 47% of men and 12% of women smoke (see table I).

Smoking rates vary widely between regions and between countries within the same region. The prevalence of smoking in men is currently highest in countries of the Western Pacific region, such as South Korea (68%), China (61%) and Japan (59%).[1] In Europe, where almost one-half of adult males are regular smokers, the prevalence ranges from 63% of men in the Russian Federation to 17% in Sweden.[2] Among women, the regional pattern of smoking is quite different, with a sharp contrast seen between prevalences in the developed world (24%) and the developing world (7%). Thus, one-third of women in Norway and Denmark smoke, compared with fewer than 5% of those in the Indian subcontinent.

In many countries the number of young people who smoke is increasing: for example, in the

Table I. Estimated smoking prevalence in those 15 years or older in the early 1990s (Reproduced from the World Health Organization,[1] with permission.)

Region	Men (%)	Women (%)
Africa	29	4
The Americas	35	22
Eastern Mediterranean	35	4
Europe	46	26
South-east Asia	44	4
Western Pacific	60	8
Developed countries	42	24
Developing countries	48	7
Global	47	12

United States, 17% of high school seniors smoked in 1992, but in 1995 this had increased to 22%.[1] This is compounded by the fact that smoking prevalence among the young is frequently high. For example, among British 15-year-olds, 28% of boys and 33% of girls are regular smokers (defined as usually smoking at least one cigarette a week).[3] Assuming that current trends in tobacco use continue, by 2030 the number of smokers worldwide will have grown to 1.64 billion, with a corresponding increase in tobacco-related diseases and deaths.[1]

As tobacco consumption rises, there is generally a lag of approximately 30 to 40 years before a resulting increase in smoking-related mortality.[1] Currently, tobacco use causes an estimated 3 million annual deaths worldwide, of which 1.9 million occur in the developed world.[1] Although the rate of increase in smoking-related mortality in the developed world shows signs of slowing among men, it continues to accelerate among women. Moreover, with the massive expansion over recent decades in tobacco consumption in the developing world, smoking-related mortality is set to rise substantially. Without concerted action, it is estimated that the number of deaths worldwide will grow to 10 million annually by 2030, with 70% of these occurring in developing countries. Tobacco is predicted to become the leading single cause of death by the 2020s, causing more than one in every eight deaths. Furthermore, half of all lifetime smokers will die prematurely as a result of tobacco use.[4]

1. Tobacco Dependence

All tobacco products contain nicotine, which is readily absorbed in the lungs, mouth and nose. Nicotine from tobacco smoke is rapidly absorbed via the pulmonary alveolar circulation and is delivered across the blood-brain barrier within 10 to 20 seconds of inhalation.[5] Nicotine is widely recognised as being highly addictive:[6] a greater proportion of casual users of tobacco graduate to addictive patterns of use than users of cocaine, morphine or alcohol.[7] Indeed, tobacco dependence is classified as a mental and behavioural disorder according to the WHO International Classification of Diseases, ICD-10.[8] As an addictive substance, nicotine displays positive reward-reinforcing properties,[9] as reflected by the compulsive drug-seeking behaviour seen in some smokers, and the appearance of an abstinence syndrome marked by withdrawal symptoms and craving after cessation of exposure (table II).[10-12]

Nicotine binds to cholinergic nicotinic receptors in the brain, autonomic ganglia and neuromuscular junctions, of which the central neuronal receptors are most relevant to the drug's behavioural effects.[9] Nicotinic receptor activation by nicotine facilitates the release of various neurotransmitters, including acetylcholine, noradrenaline, dopamine, serotonin, beta-endorphin, and gamma-aminobutyric acid (GABA). Of these, dopamine acting

Table II. Common signs and symptoms associated with nicotine withdrawal

Symptom	Incidence	
	self-quitters (%) [10]	clinical assessment (%)[11]
Irritability/aggression	38	80
Depression	31	60[12]
Anxiety	49	87
Restlessness	46	71
Poor concentration	43	73
Increased appetite	53	67
Urges to smoke	37	62
Awakenings	39	24
Decreased heart rate	61	79

through the dopaminergic mesolimbic pathway has been implicated in the behavioural reinforcing effects of nicotine.[13,14] Chronic or repeated exposure to nicotine results in sensitisation to its effects on dopamine release.[15,16] This sensitisation of mesolimbic pathways may be of relevance to the development of nicotine-craving behaviour. Independently, chronic exposure to nicotine also causes nicotinic receptor desensitisation and compensatory receptor up-regulation (i.e. an increase in nicotinic receptor density), which may account for tolerance to the psychopharmacological effects of nicotine.[17]

Although nicotine is a psychostimulant drug, smokers may experience relaxant effects and decreased tension, as well as mild euphoria and enhanced alertness, concentration and cognitive function. It is unclear whether the positive rewards of smoking (enhanced performance and mood) are due to an intrinsic enhancement effect of nicotine or to relief of symptoms of withdrawal.[9] Symptoms of nicotine withdrawal include craving, depression, anxiety, difficulty in concentrating, dysphoria, increased appetite, insomnia, irritability, frustration, anger, restlessness and decreased heart rate (see table II). Most of these symptoms peak within 48 hours after the last cigarette and then gradually decline in intensity, but some symptoms such as craving for nicotine, increased appetite and impaired concentration may continue for several months or years.[18] However, some symptoms that are thought of as withdrawal symptoms are not true withdrawal symptoms, but are direct effects of nicotine. For example, nicotine increases energy turnover, making weight control more difficult after quitting. The same can be said about attention and concentration, since these improve with nicotine use. As such, nicotine meets the criteria set down by the American Psychiatric Association 'Diagnostic and Statistical Manual of Mental Health Disorders' (DSM-IV) for definition of a drug of dependence (table III).[18]

Table III. American Psychiatric Association 'Diagnostic and Statistical Manual of Mental Health Disorders' (DSM-IV) criteria for drug dependence[18]

A maladaptive pattern of substance use, leading to clinically significant impairment or distress, as manifested by three or more of the following occurring at any time in the same 12-month period
1. Tolerance: Need for markedly increased dose to achieve desired effect OR markedly diminished effect with continued use
2. Withdrawal: The characteristic withdrawal syndrome for the substance OR the same or closely related substance is taken to relieve/avoid withdrawal symptoms
3. Substance is taken in larger doses or over a longer time than was intended
4. Persistent desire or unsuccessful efforts to cut down or control substance use
5. Much time is devoted to activities necessary to obtain/use the substance or recover from its effects
6. Important social, occupational or recreational activities are abandoned/reduced because of substance use
7. Substance use is continued despite awareness of a persistent/recurrent physical or psychological problem that is likely to have been caused/exacerbated by the substance

2. Psychosocial Correlates of Smoking Behaviour

2.1 Social Correlates

In the developed world, particularly in those with well developed anti-smoking campaigns/policies, smoking is strongly related to socioeconomic status, being more prevalent among the poor, semi-skilled manual occupation groups, the unemployed, poor educational achievers, and single mothers.[19] Moreover, this demarcation between social groups is becoming more accentuated: in the last 3 decades, smoking prevalence fell by more than 50% in the most advantaged sections of British society but remained unchanged in the most deprived groups.[20] Similarly, smoking cessation rates in the United Kingdom show a strong inverse relationship with social deprivation.

2.2 Psychiatric Correlates

Depression is an important risk factor for nicotine addiction. Smokers are more likely to have a history of major depression – and such smokers are much less likely to quit than those with no history of depression.[9] It has been suggested that this as-

sociation between depression and cigarette smoking may be due to a common genetic predisposition to the two disorders.[21] Other risk factors for nicotine addiction include schizophrenia (70 to 90% of schizophrenic patients are smokers) and polydrug abuse, in particular alcohol, cocaine and heroin.[9] As such, it is likely that most who continue to smoke will be among those with psychiatric or other social problems. Furthermore, it is likely that these smokers will be more dependent on tobacco and less interested in quitting.

3. Health Consequences of Smoking

Cigarette smoke contains some 4000 compounds, including carbon monoxide, ammonia and known carcinogens such as nitrosamines and polycyclic aromatic hydrocarbons.[22]

Tobacco-related disease is the leading cause of preventable death in much of the developed world, accounting for an estimated one in every five deaths.[23] Half of all long-term regular smokers who begin smoking during adolescence can expect to die from tobacco use, and 50% of these die prematurely during middle age, losing some 20 to 25 years of life expectancy compared with non-smokers.[4] The risk is greatest for those who start smoking regularly when teenagers.

Smoking predisposes the smoker to a large number of diseases, including many types of cancer (lung, oesophagus, bladder, kidney, stomach, pancreas), chronic obstructive pulmonary disease (COPD), coronary heart disease, stroke, peripheral vascular disease, and peptic ulcer disease. Smoking during pregnancy can cause spontaneous abortion, stillbirth, prematurity, low birthweight, and sudden infant death syndrome (SIDS).[19,24] In addition, smoking during pregnancy can also have an adverse effect on the toddler's behaviour,[25] interfere with cognitive and academic performance,[26] and increase the likelihood of the child becoming a smoker later in life.[27] In the United States, cigarette smoking is responsible for 80% of all chronic lung disease and one-third of all deaths from heart disease and cancer.[24,28]

For non-smokers, passive exposure to environmental tobacco smoke (ETS) increases the risk of lung cancer, heart disease, and respiratory illness. Among infants and children, ETS increases the risk of SIDS and causes asthma and respiratory infections. In the United Kingdom 17 000 children under the age of 5 years are hospitalised every year with illnesses caused by ETS.

3.1 Respiratory System

Smoking directly irritates and damages the respiratory tract and confers a higher risk of developing major lung diseases, including COPD (i.e. chronic bronchitis and emphysema), pneumonia, and influenza.[29] The deterioration in pulmonary function associated with COPD is directly related to the duration of smoking and the number of pack-years (the number of packs smoked per day multiplied by the duration of smoking in years).[30]

Cigarette smoking during adolescence retards lung development and reduces the level of maximum lung function, with the result that the normal age-related decline in pulmonary function starts from a lower baseline and at an earlier age.[31] Furthermore, smoking during adolescence results in mild airway obstruction and increases the risk of developing COPD in adulthood.[32]

Cigarette smoking is the major cause of all histological types of lung cancer.[29] During the past half century, lung cancer rates among women in the developed world have risen in parallel with the increase in cigarette smoking, to the extent that this is now the leading cause of female cancer deaths in the United States. Among men, the risk of lung cancer is elevated 20-fold in smokers compared with non-smokers.[33]

3.2 Cardiovascular System

Smoking acts both independently of, and synergistically with, other major risk factors for coronary heart disease. Fatal myocardial infarction is 4-times more common in young male smokers than in non-smokers of the same age.[34] Similarly, the progression of atherosclerosis in the carotid arteries is directly related to total pack-years of tobacco

exposure, and may be cumulative and irreversible.[35] Furthermore, the relative risk of stroke increases about 3-fold with smoking and is dependent on the number of cigarettes smoked.[36]

Smoking is also a risk factor for transient ischaemic attacks[37] and peripheral vascular disease, in particular Buerger's disease, a progressive inflammatory occlusive condition, which frequently necessitates limb amputation.[34]

3.3 Gastrointestinal System

Smoking is a risk factor for oral, oesophageal, pancreatic and colorectal cancers.[38,39] For example, pancreatic cancer is twice as common among smokers as in non-smokers.[33] The risk of developing gastric and duodenal ulcers[40,41] or Crohn's disease[42] increases with smoking: furthermore, the prognosis for these diseases improves in patients who stop smoking compared with those who do not.[43,44] In contrast, smoking has a protective effect in ulcerative colitis.[45]

3.4 Reproduction and Growth

Smoking during pregnancy adversely affects the fetus and, in later years, ETS can affect the neonatal infant and the growing child.[46] Adverse sequelae include an increased risk of miscarriage (2- to 3-fold), stillbirth, low birthweight (4-fold increase in risk), SIDS, and impaired physical and intellectual development.[46-49]

3.5 Other Systems

Smoking has been associated with a 40% increase in the risk of cataracts[47] and a 2- to 3-fold increase in risk of macular degeneration.[50,51] Some studies have also linked smoking with premature wrinkling, atopic dermatitis[52] and psoriasis.[53] Smoking is also associated with loss of bone mineral density and osteoporosis in the elderly,[54,55] and has been implicated as a contributory factor in one in eight hip fractures.[55] In the genito-urinary system, smoking is a risk factor for renal and bladder cancers.[56]

4. Costs Associated with Smoking

Tobacco use is associated with huge societal and economic costs arising from the healthcare burden of smoking-related morbidity and mortality. These include the costs imposed by smokers (use of healthcare resources, absence from work, loss of productivity, statutory sick pay, etc.) and the costs of the harmful effects of ETS on non-smokers.

The treatment of smoking-related morbidity represents a significant cost burden to healthcare providers. According to World Bank estimates, smoking-related expenditure accounts for 6 to 15% of total annual healthcare costs in high-income countries.[57] In the United Kingdom, smoking-related illness costs the National Health Service an estimated £1.5 billion each year.[58] By 2030, four-fifths of smokers will be in developing countries, and the economic costs associated with tobacco-related diseases are likely to impose a serious strain on their limited healthcare resources. Against this background, smoking cessation treatments represent some of the most cost effective of all healthcare interventions.[58,59]

5. Health Benefits of Smoking Cessation

People who smoke for 10 years or more show a substantially higher rate of death, disease and disability than non-smokers. Nevertheless, many smoking-related adverse effects are reversible upon smoking cessation. Although risks to the respiratory system in particular continue to plague the ex-smoker for years after quitting, risks to certain other organ systems decline in accordance with the duration of abstinence.[56] While the greatest benefit is obtained from stopping smoking when young, even quitting in middle age avoids much of the excess risk,[60] so that 15 years after quitting smoking the risk of death among ex-smokers is no greater than the risk in those who have never smoked.[56]

5.1 Respiratory System

Pulmonary function improves by approximately 5% within several months of quitting smoking;[30] with sustained abstinence, the rate of decline in pulmonary function continues to slow and the risk of COPD diminishes (figure 1).[61] Likewise, smoking cessation reduces the risk of lung cancer, the severity and progression of premalignant histological changes, and the risk of further neoplasms. Smoking cessation also improves survival rates in patients who have cancer.[56,62] The magnitude of the reduction in cancer risk increases with the duration of abstinence: after 10 years the risk is reduced by 30 to 50%.[63]

5.2 Cardiovascular System

The excess risk of coronary heart disease halves within one year of stopping smoking, and after 15 years is equivalent to that in non-smokers.[56] Likewise, the excess risk of stroke is reported to return to that of non-smokers within 5 to 15 years of smoking cessation,[57] although this claim is disputed by a more recent study suggesting that an elevated risk persists for at least 20 years after cessation.[64] For patients with peripheral vascular disease, the prognosis is considerably improved by stopping smoking.[56]

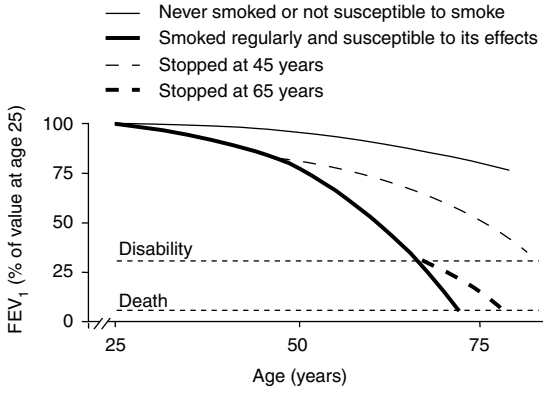

Fig. 1. The effect of smoking on lung function with age. **FEV_1** = forced expiratory volume in 1 second. (Reproduced with permission from Fletcher C, Peto R. The natural history of chronic airflow obstruction. BMJ 1977; 1: 1645-8.[61] Copyright© BMJ Publishing Group.)

5.3 Gastrointestinal System

In general, patients with Crohn's disease who stop smoking for at least a year have a more benign disease course – similar to that in non-smokers. During a prospective 12- to 18-month cohort study, the rate of Crohn's disease flare-up in those who continued to smoke (46%) was twice that in those who stopped smoking (23%).[65] Similarly, fewer duodenal ulcer relapses were reported in former smokers (14%) compared with those who continued to smoke (25%) during maintenance therapy with ranitidine.[66]

Clear reductions in colorectal cancer mortality rates have been observed in former smokers compared with those who continued to smoke, although the rates were lowest among lifelong non-smokers.[67]

5.4 Reproduction and Growth

It is suggested that smoking reduces fecundity, and women who have difficulty conceiving are recommended to stop smoking.[68] Furthermore, smoking cessation in pregnancy is considered the most effective method of reducing negative pregnancy outcomes such as fetal growth retardation, preterm delivery and perinatal mortality.[69]

5.5 Other Systems

The risk of oral and oesophageal cancer halves within 5 years of smoking cessation, although it remains elevated compared with that in non-smokers. Similarly, the risk of pancreatic cancer declines after quitting smoking, albeit only partially. The risk of bladder cancer is halved within a few years of quitting smoking, but nevertheless remains elevated for decades.[56]

6. Long-Term Management of Smoking Cessation

Cigarette smoking is a highly addictive behaviour: even after an acute myocardial infarction, half of smokers continue with the habit. As most smokers who do attempt to quit require multiple attempts before finally succeeding, tobacco depend-

ence can be considered a chronic, relapsing disorder.[70] While in countries with the good anti-smoking campaigns/policies up to 80% (54% in the European Union) of smokers state that they want to quit, fewer than half succeed in stopping permanently before the age of 60 years.[1]

In order to improve smoking cessation rates, effective treatment is needed. Current smoking cessation interventions include behavioural and pharmacological treatments, with pharmacotherapy (such as sustained-release bupropion and nicotine replacement therapy) being the recommended first-line approach.[70-72] However, the success of these interventions depends not only on the motivation of the individual to quit smoking, but also on the availability of health professionals to help the patient choose the level of required support that is appropriate to their needs. Since smoking duration is the risk factor for smoking-related morbidity, the treatment goal should be cessation as early as possible in the course of the addiction, coupled with prevention of relapse.

In conclusion, smoking cessation is associated with numerous short- and long-term health and economic benefits. The greatest benefit accrues from smoking cessation when young, but even quitting in middle age avoids much of the healthcare risk and the associated cost of treatment. As such, great efforts should be made to reduce the prevalence of smoking worldwide, particularly in developing countries where smoking is on the increase.

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