

Smoking and reproduction

Introduction

This fact sheet explains how smoking affects fertility in both men and women. It reviews the harm caused by smoking during pregnancy as well as some of the longer-term risks to the health of children born to parents who smoke.

A published review of the literature examining the relationship between smoking and fertility concluded that tobacco use affects every system involved in the reproductive process.¹ This finding is supported by a systematic review of the scientific literature on the impact of cigarette smoking and smoke constituents on the different stages of reproductive function which found that “all stages of reproductive functions are targets of cigarette smoke toxicants.”²

A study published by the US Centers for Disease Control and Prevention notes that while smoking rates amongst pregnant women in the Western world have fallen in recent years, smoking remains a major cause of new-born deaths, early births and babies born with low birth weight. Researchers found that smoking was associated with:

- 5-8% of premature births
- 13-19% of cases of low birth weight in babies carried to full term
- 5-7% of preterm-related deaths
- 23-34% of deaths caused by sudden infant death syndrome (cot death).³

In the UK, smoking in pregnancy causes up to 5,000 miscarriages, 300 peri-natal deaths and around 2,200 premature births each year.⁴

Female fertility

Research has established beyond doubt that smoking can have a negative impact on female fertility. Women who smoke take longer to conceive than women who do not smoke.⁵

One study found that tobacco consumption affects uterine receptivity, with heavy smokers more likely to be affected.⁶ However, even comparatively low levels of smoking can have a significant impact on female fertility. There is also a higher rate of ectopic pregnancies in smokers.^{7,8}

There is evidence to suggest that smoking reduces the success rates of fertility treatment.⁹ Studies of women undergoing assisted reproductive treatment have demonstrated a significant negative effect associated with smoking.^{10,11,12} One study in the 1990s showed a 50% reduction in implantation rate among smokers compared to women who had never smoked.¹³

A growing body of research suggests that maternal smoking may have a negative impact on the fertility of both female and male off-spring.^{14,15,16} Smoking during pregnancy reduces the number of germ cells (the cells that form eggs in females and sperm in males) and somatic cells (the cells that form every other part of the body) that form in the developing foetus.¹⁷ Smoking during

pregnancy also has an impact on protamine, a protein essential in sperm production which can lead to fertility problems.¹⁸ However, further research into this issue is needed before a causal link can be definitively established.

Male fertility & sexual impotence

Cigarette smoking affects male fertility, even starting in utero. Studies show that men whose mothers smoked while pregnant are at risk of having smaller testes,¹⁹ lower mean sperm concentration and lower total sperm counts.^{20,13}

Men who smoke have a lower sperm count than non-smokers, and their semen contains a higher proportion of malformed sperm.^{21,22,23} By-products of nicotine present in the semen of smokers have been found to reduce the motility of sperm and their fertilization capacity.^{23,24} While there is a correlation between the number of cigarettes smoked and the damage to sperm, researchers have found that there is no “safe” level of smoking. Even light smoking is associated with reduced male fertility.^{21,25}

Mounting evidence shows a significant association between smoking and male sexual impotence with the association increasing with the number of cigarettes smoked per day.^{26,27,28,29,30}

Smoking in pregnancy

In March 2011, the Government set a target to reduce the percentage of women who smoked during pregnancy from 14% to 11% by 2015 (measured at the time of birth).³¹ By March 2012 the proportion of women smoking at the time of delivery was 13%. This equates to about 83,000 infants born to smoking mothers each year.³²

Prevalence of smoking in pregnancy

The 2010 Infant Feeding Survey found that 26% of mothers smoked in the 12 months before or during their pregnancy, which was down from 33% in 2005.³³

Over half (54%) of women who smoked before pregnancy managed to stop once they became pregnant but 12% of mothers-to-be continued to smoke throughout their pregnancy, down from 17% in 2005.³³ By 2010, the percentage of mothers reported to be smoking at delivery in England had dropped to 14%. It is worth noting, however, that numerous researchers have argued that these figures rely on self-reporting and, as such, are unlikely to be accurate.^{34,35} Smoking rates also vary significantly throughout the UK.³⁶

Younger mothers, women in disadvantaged circumstances and who have never worked tend to be more likely to smoke throughout their pregnancy.^{33,37} In 2010, mothers under the age of 20 were nearly four times as likely to smoke before or during pregnancy, compared to mothers aged 35 or over (57% compared with 15%).³³

Foetal growth and birth weight

Maternal smoking is a major risk factor for low birth weight and babies who are small for their gestational age (SGA).^{38,39,40,41} Research in Sweden has shown that babies born to women who smoke throughout their pregnancy are on average 162-226 grams lighter than babies born to non-smoking mothers.⁴² Spanish researchers found the mean difference in their study subjects to be 216 grams.⁴³ One study reported that approximately 30% of growth-restricted neonates could be independently associated with maternal smoking.⁴⁴ Others found that smoking during pregnancy can lead to slower growth of the foetus' head⁴⁵ and smaller head circumference at birth.^{46,47}

Perinatal mortality and Sudden Infant Death Syndrome

Perinatal mortality includes still-birth (loss of the foetus after the 24th week of pregnancy) and neonatal death (death of the newborn within the first four weeks of life). It is estimated that about one-third of all perinatal deaths in the UK are caused by maternal smoking.⁴⁸ This equates to approximately 300 deaths per year. Evidence from the West Midlands has demonstrated that “babies born to women who smoke during pregnancy are around 40% more likely to die within the first four weeks of life than babies born to non-smokers.”^{41,49}

More than one-quarter of the risk of death due to Sudden Infant Death Syndrome (cot death) is attributable to smoking during pregnancy and exposure to secondhand smoke, particularly in the home.^{50,51,52,53} The risk of cot death is trebled in infants whose mothers smoke both during and after pregnancy.⁵⁴ The greater the number of cigarettes smoked, the higher the risk of cot death.^{54,55} One possible explanation for this is that nicotine and its derivatives easily reach the cerebrospinal fluid in the foetus, causing damage to the ependymal (the lining providing a protective barrier and filtration system separating the brain from cerebrospinal fluid).⁵⁶ One way to help reduce the risk of cot death is to maintain a smoke-free home and vehicle at all times.⁵⁷

Pre-term birth is a major clinical problem, accounting for about half of all neonatal deaths. Recent research in Sweden examined the relationship between maternal smoking and pre-term birth and found that, compared to non-smokers, moderate smokers had a two-fold increase in risk of preterm labour, which rose to two and a half times greater risk among heavy smokers.⁵⁸ Maternal smoking negatively impacts offspring from infancy to childhood and even into adulthood.

Maternal smoking and child health

Infants and children of parents who smoke are twice as likely to suffer from a serious **respiratory infection** as the children of non-smokers. Smoking during pregnancy can also increase the risk of **asthma and wheezing** in young children.^{59,60,61} Research suggests that the increased risk of asthma and respiratory infections may be due to changes in biological receptors in the baby’s immune system that are responsible for recognising and fighting infections and bacteria.⁶² Smoking in pregnancy is also associated with an increased risk of **infantile colic**.^{63,64}

Smoking in pregnancy may also have implications for the **long term physical growth and intellectual development** of the child.^{65,66}

There is also evidence that smoking interferes with a woman’s **hormonal balance** during pregnancy and that this may have long-term consequences on the reproductive organs of her children.⁶⁷ (See fertility sections above.)

A 27 year study examining cholesterol in children found evidence suggesting that maternal smoking in pregnancy is associated with an increased rise in total **cholesterol** levels and a tendency towards an adverse lipoprotein profile in the offspring.⁶⁸ Another study concluded that smoking among pregnant women is independently associated with significantly lower high-density lipoprotein cholesterol in healthy 8-year-olds.⁶⁹ Adults who were small for gestational age at birth as a result of maternal smoking also have an increased risk of hypercholesterolemia (high cholesterol).⁷⁰

Other risks of smoking during pregnancy

Although it is important to recognize that there may be confounding factors that also contribute to these risk factors,⁷¹ further impacts include:

- Increased risk of **congenital defects** in the offspring of smokers,⁷² including orofacial clefts;^{73,74,75,76} neural tube defects (defects of the brain, spine, or spinal cord);^{77,78} cardiovascular/heart defects; musculoskeletal defects, limb reduction defects; missing/extra digits; clubfoot; craniosynostosis (fused skull bones that may affect brain growth); facial defects; eye defects; gastrointestinal defects; gastroschisis (intestines and possibly other organs protrude from a hole beside the baby's navel); anal atresia; hernia; and undescended testes.⁷⁶
- Early developmental exposure to cigarette smoke can result in epigenetic changes in the lungs of the offspring which can be transferred to following generations, resulting in adult onset of respiratory disease.⁷⁹ Some evidence shows an association between maternal smoking, early childhood exposure to secondhand smoke and the development of **emphysema in adulthood**. The findings suggest that the lungs may not recover completely from the effects of early-life exposure.^{80,81}
- Researchers have also found that adults exposed to tobacco smoke in utero had a more adverse **cardiovascular disease risk** profile.⁸² There is even evidence that prenatal and postnatal secondhand smoke contributes to insulin resistance in children.⁸³
- One study found that maternal smoking during pregnancy is linked to high foetal testosterone (FT), which leads to an increased risk for **autism, ADHD, conduct disorder and antisocial behaviour**.⁸⁴ Numerous other studies have demonstrated a link between maternal smoking and ADHD,^{85,86,87} as well as new research linking secondhand smoke and ADHD.⁸⁸
- A population level study of children in Finland found that the risk of **psychiatric morbidity** was significantly higher in the children of mothers who smoked during pregnancy.⁸⁹
- Studies have found that smoking during pregnancy and exposure to secondhand smoke in early childhood were “quite strong” predictors of **conduct problems, anti-social behaviour** and crime later in life.^{90,91,92}
- This finding is supported by other studies exploring the relationship between maternal smoking during pregnancy and **behaviour problems** in childhood and adolescence,^{93,94,95,96,97,98} including **smoking** (particularly among girls)⁹⁹ and other **substance use**.^{100,101,102}
- Maternal smoking has been associated with an increased risk of **learning difficulties**.¹⁰³
- Some evidence suggests that prenatal exposure to tobacco smoke may be associated with **benign breast disease** later in life.¹⁰⁴
- There is strong evidence that **childhood overweight and obesity** can be related to smoking during pregnancy.^{105,106,107,108} Two meta-analyses of 7 and 14 studies respectively found that, for children of mothers who smoked during pregnancy, there was a 47-50% increase in the odds of being overweight in childhood.^{109,110}

Passive smoking and pregnancy

Secondhand tobacco smoke is a mixture of at least 4,000 chemical compounds,¹¹¹ dozens of which are known or suspected reproductive toxins.¹³

Non-smoking women exposed to other people's tobacco smoke during pregnancy are more likely to have lower weight babies.¹¹² On average, infants born to women exposed to secondhand smoke during pregnancy are 25-40g lighter than those born to women who are not exposed.¹³ Babies born to non-smoking women whose partners smoke have been found to weigh less than babies born to non-smoking couples.^{113,114}

Other research suggests that non-smoking women who are exposed to second-hand smoke are at increased risk of difficulty becoming pregnant,^{13,115} of giving birth prematurely or stillbirth,^{116,117} of spontaneous abortion^{115,118} and of having a baby with congenital malformations.¹³

Additionally, some evidence suggests that female fertility can be damaged in utero if the woman's mother was exposed to secondhand smoke while pregnant.^{13,67,119}

It has been found that exposure to secondhand smoke can also be damaging in terms of successful pregnancy outcomes for women undergoing in vitro fertilization (IVF) or other Assisted Reproductive Technology (ART) treatment.^{120,121,122}

Attention deficit and hyperactivity have also been linked to secondhand smoke exposure in the home, in addition to maternal smoking during pregnancy.¹²³

Exposure to parental secondhand smoke in the home and vehicle is strongly associated with middle ear disease in children.¹²⁴

Some studies show evidence of prenatal and postnatal secondhand smoke causing leukaemia,^{125,126} particularly acute lymphoblastic leukaemia.^{127,128,129}

Research on the reproductive effects of secondhand smoke exposure is relatively new compared to the effects of active smoking. More epidemiologic research is likely to reveal additional negative health effects, as well as the mechanisms whereby they occur and the dose-response relationships involved.¹³ Studies related to genetics and reproduction among smokers are also emerging and will continue to shed light on the processes involved.^{130,131}

Breast-feeding

Women who have quit smoking for at least a month are more apt to initiate breastfeeding.¹³² In addition, women who quit smoking tend to continue breastfeeding for a longer period of time than those who continue to smoke.¹³³ Women may not be aware that breastfeeding is still recommended by the National Health Service (NHS)¹³⁴ and the American Academy of Pediatrics,¹³⁵ among others, because of its beneficial effects on the baby, even if the mother continues to smoke.^{136,137} Health professionals should therefore combine smoking cessation and relapse prevention advice with lactation counselling to maximize success of smokers' efforts to initiate breastfeeding.^{138,139}

Smoking and oral contraception

Women who use combined oral contraceptives are at increased risk of heart disease. Because the risk of heart disease in young women is low, the benefits of using the pill generally outweigh the risks for young women who do not smoke. Pill-users who smoke are also at risk of venous thromboembolism and arterial thrombosis.^{140,141,142} It is therefore important that all women who take the contraceptive pill be advised not to smoke.

Smoking and the menopause

Smoking is associated with early onset of menopause^{143,144} with the natural menopause occurring up to two years earlier in smokers.¹⁴⁵ The likelihood of an earlier menopause is related to the number of cigarettes smoked, with those smoking more than ten cigarettes a day having an increased risk of an early menopause.¹⁴⁶

Stopping smoking may lower the risk of early menopause. While current smokers' risk of early menopause is twice that of non-smokers, in ex-smokers the risk is higher by just one-third. Research suggests that polycyclic aromatic hydrocarbons found in tobacco smoke can

trigger premature egg cell death which may in turn lead to earlier menopause.¹⁴⁷ Another study suggests that chemicals in tobacco smoke alter endocrine function which in turn affects the release of pituitary hormones. This endocrine disruption is thought to contribute to adverse outcomes including earlier menopause.¹⁴⁸

Quitting smoking during pregnancy

More women quit smoking when they are pregnant than at any other time during their lives.¹⁴⁹ In fact, pregnant smokers are twice as likely to attempt to quit smoking as non-pregnant women, but only about half of pregnant women actually stop smoking during pregnancy.¹⁵⁰ In 2011-12 in the UK, 26,080 pregnant women set a quit date with NHS Stop Smoking Services and 45% of them (11,623) successfully quit.¹⁵¹

Because smoking poses a high risk of harm to both mother and foetus, it is important that pregnant women be supported to help them stop smoking at least for the duration of the pregnancy, but also postpartum. The NHS Pregnancy Smoking Helpline (0800 169 9 169) provides a call-back service that helps support women smokers throughout their pregnancy. However, support should come from the baby's father, family members and friends, as well as the health care system.

A 2009 Cochrane review found that interventions from health professionals reduced the proportion of women smoking in late pregnancy by about 6% overall.¹⁵² The most effective intervention, particularly among low income women, appeared to be providing incentives,¹⁵³ which helped around 24% of women in one study to quit smoking during pregnancy.¹⁵²

The Department of Health has published guidance on stop smoking interventions in primary and secondary care which recommends establishing treatment pathways for all smokers including pregnant women.⁴¹ The National Institute for Health and Clinical Excellence (NICE) has also published guidance on stopping smoking in pregnancy and following childbirth.¹⁵⁴ ASH UK recently produced Smoking cessation in pregnancy: A call to action, designed to encourage health care professionals to work together to reduce smoking during pregnancy.¹⁵⁵

Smoking cessation interventions have been shown to reduce the number of newborns with low birth weight and preterm births.¹⁵² In one study, compared to ongoing heavy smoking, quitting was associated with a 299g increase in birth weight and going from heavy to light smoking was associated with a 199g increase in birth weight, while the babies of light smokers who quit entirely saw a 63g increase in birth weight.¹⁵⁶

The outcome is worth it, but it is still difficult for some women to quit smoking and they may need pharmacotherapy support. A recent review of the efficacy and safety of nicotine replacement therapy (NRT) in pregnancy concluded that there was insufficient evidence to determine whether or not NRT is effective or safe when used in pregnancy.¹⁵⁷ However, compared with continuing to smoke, getting nicotine from NRT is likely far safer.¹⁵⁷

A US review of studies found that NRT use significantly decreased the risk of preterm delivery and low birth weight compared to that of smokers and also found that NRT use does not appear to increase the risk of malformations.¹⁵⁸

Since NRT is metabolised up to 60% faster by pregnant women, higher doses of NRT may be needed.⁴¹ ¹⁵⁷ Additional research is needed on which types and doses of NRT are the most effective in helping pregnant smokers quit, while also protecting the foetus.¹⁵⁷

Currently, the National Institute for Health and Care Excellence (NICE) only recommends the use of NRT by pregnant women if they have been unable to quit on their own.¹⁵⁹

Bupropion is also prescribed as a smoking cessation aid during pregnancy,^{160,161,162} but NICE does not recommend its use by pregnant or breastfeeding women.¹⁵⁹

The use of varenicline is also not recommended during pregnancy.¹⁵⁹

Even with pharmacotherapeutic, professional and social support, quitting is hard for some people due to their physical, psychological and social addictions to smoking. Many women will quit during their pregnancy, but the rate of relapse postpartum is high and this period should continue to be a focus for providing support to new mothers.¹⁶³

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