

# 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.<sup>1</sup> 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.”<sup>2</sup>

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).<sup>3</sup>

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

## 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.<sup>5</sup>

One study found that tobacco consumption affects uterine receptivity, with heavy smokers more likely to be affected.<sup>6</sup> 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.<sup>7,8</sup>

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

A growing body of research suggests that maternal smoking may have a negative impact on the fertility of both female and male off-spring.<sup>14,15,16</sup> 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.<sup>17</sup> Smoking during

pregnancy also has an impact on protamine, a protein essential in sperm production which can lead to fertility problems.<sup>18</sup> 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. In one animal study female mice were exposed to cigarette smoke before and after becoming pregnant. The male offspring were observed to have depleted sperm counts, damage to germ cell DNA and deviant testicular development.<sup>19</sup> Other studies further show that men whose mothers smoked while pregnant are at risk of having smaller testes,<sup>20</sup> lower mean sperm concentration and lower total sperm counts.<sup>21</sup>

Men who smoke have a lower sperm count than non-smokers, and their semen contains a higher proportion of malformed sperm.<sup>22,23,24</sup> By-products of nicotine present in the semen of smokers have been found to reduce the motility of sperm and their fertilization capacity.<sup>24,25</sup> 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.<sup>22,26</sup>

Mounting evidence shows a significant association between smoking and male sexual impotence with the association increasing with the number of cigarettes smoked per day.<sup>27,28,29,30,31</sup>

### **Smoking in pregnancy**

Younger mothers, women in disadvantaged circumstances and who have never worked tend to be more likely to smoke throughout their pregnancy.<sup>32</sup>

In March 2011, as part of the Tobacco Control Plan for England, the Government set an ambition to reduce the percentage of women who smoked during pregnancy from 14% to 11% by 2015 (measured at the time of birth).<sup>33</sup>

In response to a challenge from the then Public Health Minister to produce recommendations on how the ambition could be achieved, the Smoking in Pregnancy Challenge Group was established. This is a partnership of experts from academia, medical colleges and the third sector.<sup>34</sup>

By April 2016, 10.6% of women were smoking at the time of delivery, making this the first year that annual figures have been below the 11% target. However, this still equates to just over 67,000 infants born to smoking mothers in England.<sup>35</sup>

Following the attainment of the Government’s 11% target, the Smoking in Pregnancy Challenge Group has proposed a new target to reduce the percentage of women smoking during pregnancy to 6% or less by 2020.<sup>36</sup>

### **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).<sup>37,38,39,40</sup> 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.<sup>41</sup> Spanish researchers found the mean difference in their study subjects to be 216 grams.<sup>42</sup> One study reported that approximately 30% of growth-restricted neonates could be independently associated with maternal smoking.<sup>43</sup> Others found that smoking during pregnancy can lead to slower growth of the foetus’ head<sup>44</sup> and smaller head circumference at birth.<sup>45,46</sup>

## 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.<sup>47</sup> 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.”<sup>40,48</sup>

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.<sup>49,50,51,52</sup> The risk of cot death is trebled in infants whose mothers smoke both during and after pregnancy.<sup>53</sup> The greater the number of cigarettes smoked, the higher the risk of cot death.<sup>53,54</sup> One possible explanation for this is that nicotine and its derivatives found in tobacco smoke 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).<sup>55</sup> One way to help reduce the risk of cot death is to maintain a smoke-free home and vehicle at all times.<sup>56</sup>

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.<sup>57</sup> 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.<sup>58,59,60</sup> The effects of maternal smoking during pregnancy and childhood environmental tobacco smoke (ETS) exposure on asthma and wheezing were investigated in 5,762 school-aged children in California. Maternal smoking during pregnancy was consistently associated with varying forms of both asthma and wheezing. In contrast current and previous ETS exposure was not associated with asthma but was associated with subcategories of wheezing.<sup>61</sup> 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.<sup>62</sup> Smoking in pregnancy is also associated with an increased risk of **infantile colic**.<sup>63,64</sup>

Smoking in pregnancy may also have implications for the **long term physical growth and intellectual development** of the child.<sup>65,66</sup>

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.<sup>67</sup> (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.<sup>68</sup> Another study concluded that smoking among pregnant women is independently associated with significantly lower high-density lipoprotein cholesterol in healthy 8-year-olds.<sup>69</sup> Adults who were small for gestational age at birth as a result of maternal smoking also have an increased risk of hypercholesterolemia (high cholesterol).<sup>70</sup>

There is also evidence of a link between maternal smoking during pregnancy and risk of childhood cancer. In a case-control study researchers observed a dose-response relationship between the number of cigarettes smoked per day by the mother during pregnancy and cancer risk in offspring. Compared to a control group the risk for the experimental group was doubled for non-Hodgkin lymphoma, acute lymphoblastic leukaemia, and Wilms' tumour.<sup>71</sup> More recent research has supported this finding that there is a link between maternal smoking and risk of childhood cancer.<sup>72,73</sup>

Although confounding bias (i.e. a situation in which the effect or association between an exposure and outcome is distorted by the presence of another variable) may contribute to these risk factors,<sup>74</sup> further impacts include:

- Increased risk of **congenital defects** in the offspring of smokers,<sup>75</sup> including orofacial clefts;<sup>76,77,78,79</sup> neural tube defects (defects of the brain, spine, or spinal cord);<sup>80,81</sup> 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.<sup>79</sup>
- 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.<sup>82</sup> (Epigenetics is the study of biological mechanisms that switch genes on and off.) 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.<sup>83,84</sup>
- Researchers have also found that adults exposed to tobacco smoke in utero had a more adverse **cardiovascular disease risk** profile.<sup>85</sup> There is even evidence that prenatal and postnatal secondhand smoke contributes to insulin resistance in children.<sup>86</sup>
- 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**.<sup>87</sup> Numerous other studies have demonstrated a link between maternal smoking and ADHD,<sup>88,89,90</sup> as well as new research linking secondhand smoke and ADHD.<sup>91</sup>
- A study examining causal relationships found that maternal smoking is associated with increased conduct problems and the externalising of problems in children. A limited association was found with hyperactivity and problems with peers.<sup>92</sup>
- 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.<sup>93</sup>
- 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.<sup>94,95,96</sup>
- This finding is supported by other studies exploring the relationship between maternal smoking during pregnancy and **behaviour problems** in childhood and adolescence,<sup>97,98,99,100,101,102</sup> including **smoking** (particularly among girls)<sup>103,104</sup> and other **substance use**.<sup>105,106,107</sup>
- Maternal smoking has been associated with an increased risk of **learning difficulties**.<sup>108</sup>
- Some evidence suggests that prenatal exposure to tobacco smoke may be associated with **benign breast disease** later in life.<sup>109</sup>
- There is strong evidence that **childhood overweight and obesity** can be related to smoking during pregnancy.<sup>110,111,112,113,114</sup> 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.<sup>115,116</sup>

## Passive smoking and pregnancy

Secondhand tobacco smoke is a mixture of at least 4,000 chemical compounds,<sup>117</sup> dozens of which are known or suspected reproductive toxins.<sup>13</sup>

Non-smoking women exposed to other people's tobacco smoke during pregnancy are more likely to have lower weight babies.<sup>118</sup> 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.<sup>13</sup> Babies born to non-smoking women whose partners smoke have been found to weigh less than babies born to non-smoking couples.<sup>120,121</sup> Exposure to second-hand smoke has also been significantly associated with preterm births.<sup>122</sup> Other research suggests that non-smoking women who are exposed to second-hand smoke are at increased risk of difficulty becoming pregnant,<sup>13,123</sup> of giving birth prematurely or stillbirth,<sup>124,125</sup> of spontaneous abortion<sup>123,126</sup> and of having a baby with congenital malformations.<sup>13</sup>

Additionally, some evidence suggests that female fertility can be damaged in utero if the woman's mother was exposed to secondhand smoke while pregnant.<sup>13,67,127</sup>

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.<sup>128,129,130</sup>

Attention deficit and hyperactivity have also been linked to secondhand smoke exposure in the home, in addition to maternal smoking during pregnancy.<sup>131</sup>

Exposure to parental secondhand smoke in the home and vehicle is strongly associated with middle ear disease in children.<sup>132</sup>

Some studies show evidence of prenatal and postnatal secondhand smoke causing leukaemia,<sup>133,134</sup> particularly acute lymphoblastic leukaemia.<sup>135,136,137</sup>

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.<sup>13</sup> Studies related to genetics and reproduction among smokers are also emerging and will continue to shed light on the processes involved.<sup>138,139</sup>

## Breast-feeding

Women who have quit smoking for at least a month are more apt to initiate breastfeeding.<sup>140</sup> In addition, women who quit smoking tend to continue breastfeeding for a longer period of time than those who continue to smoke.<sup>11</sup> A study of Canadian women found maternal smoking was negatively associated with 6 months exclusive breastfeeding.<sup>142</sup> Women may not be aware that breastfeeding is still recommended by the National Health Service (NHS)<sup>143</sup> and the American Academy of Pediatrics,<sup>144</sup> among others, because of its beneficial effects on the baby, even if the mother continues to smoke.<sup>145,146</sup> Health professionals should therefore combine smoking cessation and relapse prevention advice with lactation counselling to maximize success of smokers' efforts to initiate breastfeeding.<sup>147,148</sup>

## 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 (blood clots in the veins and arteries).<sup>149,150,151</sup> 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<sup>152,153</sup> with the natural menopause occurring up to two years earlier in smokers.<sup>154</sup> 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.<sup>155</sup>

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.<sup>156</sup> 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.<sup>157</sup>

### Quitting smoking during pregnancy

More women quit smoking when they are pregnant than at any other time during their lives.<sup>158</sup> One study found that pregnant smokers were twice as likely to attempt to quit smoking as non-pregnant women<sup>159</sup> but surveys suggest that less than half of pregnant women smokers actually stop smoking during pregnancy. For example, in England, in 2015-16 17,743 pregnant women set a quit date with NHS Stop Smoking Services and 45% of them (7,914) successfully quit.<sup>160</sup> This is down from the 8,838 women who successfully quit in 2014-15.<sup>161</sup>

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.<sup>162</sup>

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.<sup>40</sup> The National Institute for Health and Clinical Excellence (NICE) has also published guidance on stopping smoking in pregnancy and following childbirth.<sup>163</sup>

In March 2012, following a challenge by the Public Health Minister to investigate ways of further reducing the rate of smoking in pregnancy, the Smoking in Pregnancy Challenge Group was established to encourage health care professionals to work together towards this goal.<sup>164</sup> A follow-up report to measure progress was published in October 2015.<sup>165</sup>

Smoking cessation interventions have been shown to reduce the number of newborns with low birth weight and preterm births.<sup>162</sup> 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.<sup>166</sup>

As stopping smoking can be difficult, some women may need pharmacotherapy support. A review of the efficacy and safety of nicotine replacement therapy (NRT) in pregnancy found that NRT increased smoking cessation rates, measured in late pregnancy, by approximately 40%.<sup>167</sup> The authors found no evidence that NRT used for smoking cessation in pregnancy has either positive or negative impacts on birth outcomes.

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.<sup>168</sup>

Since NRT is metabolised up to 60% faster by pregnant women, higher doses of NRT may be needed.<sup>167</sup> 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.<sup>167</sup>

Currently, the National Institute for Health and Care Excellence (NICE) recommends the use of NRT by pregnant women only if they have been unable to quit without NRT.<sup>169</sup>

NICE does not recommend the use of either bupropion or varenicline by pregnant or breastfeeding women.<sup>169</sup>

There is some research which suggests that financial incentives can increase quit rates among some pregnant smokers. One study found it to be the most effective intervention, particularly among low income women.<sup>170</sup>

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.<sup>171</sup> One way that they can be supported is through initiatives to make homes smoke-free, thus protecting all family members from smoke exposure and reducing the chances of relapse.

### **Other resources**

[Use of Electronic Cigarettes in Pregnancy: a guide for midwives and other healthcare professionals](#), Smoking in Pregnancy Challenge Group, 2016

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