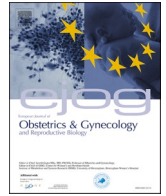


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The effects of climate change and environmental pollution on human reproduction: A scientific review commissioned by the European Board and College of Obstetrics and Gynaecology (EBCOG)

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ABSTRACT

The European Board and College of Obstetrics and Gynaecology (EBCOG) and the European Network of Trainees in Obstetrics and Gynaecology (ENTOG) express their concerns on the effect of climate change and environmental pollution. This paper reviews the impact on reproductive health and the contribution to climate change by the field of obstetrics and gynaecology. It concludes that its contributors and the effects of climate change cause definite adverse consequences to fertility and adverse obstetric outcomes. Mankind, and obstetrics and gynaecology personnel as well, must be aware and responsible of its contribution to climate change and consider the impact of their actions and interventions.

Introduction

Human activities over the last two centuries have contributed towards significant changes in ecology that involve marked alterations in ambient climate. These changes and the drivers behind these changes, not only bring about catastrophic implications to the environment, but also have serious implications to human health including reproductive health. The European Board and College of Obstetrics and Gynaecology (EBCOG) and the European Network of Trainees in Obstetrics and Gynaecology (ENTOG) express their concerns on climate change, the impact on reproductive health and the impact of professionals in the field of obstetrics and gynaecology. It is essential that reproductive healthcare workers appreciate more closely the mechanisms and effects of climate change on reproductive health so that measures can be taken to respond to the risks thus preventing increasingly adverse maternal and neonatal outcomes. The reproductive issues related to climate change transcend beyond the increased risk of injury that pregnancy

women are suspect to during a major natural disaster. Climate change has been brought about by adverse alterations in the environment have been brought about by human activities that have polluted the world we live in. These pollutants can directly further aggravate adverse effects on male and female reproduction.

Effects of temperature stress on reproductive health

It is now generally recognised that climate change is unequivocally caused by human activity, primarily through emissions of greenhouse gasses and air-borne fine particles, resulting in damage to the world's protective ozone layer leading to global warming. According to the 2023 Annual Climate Report of the National Oceanic and Atmospheric Administration (NOAA), the combined land and ocean temperature has increased at an average rate of 0.06 °C per decade since 1850. The rate of warming since 1982 has however been at least three times as fast with an average rate of 0.20 °C per decade [1]. Should the trend persists than

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more and more people will be forced to live outside appropriate environmental niches where the ambient wet-bulb temperature is ≥ 35 °C, theorized on physiological principles to be the limit of human adaptability to the ambient environment. Studies have however shown that heat stress in young health adults can become uncompensable at even lower wet-bulb temperatures being further dependent environmental humidity [2]. The core body temperatures of people living in regions with such ambient temperatures can rise to ≥ 40 °C resulting in significant physiological manifestations leading to different forms of heat-related illness, including heat stroke [3].

Elevated core body temperature has been associated with lower fertility in males primarily by affecting spermatogenesis leading to low sperm counts, poor sperm motility and abnormal sperm morphology in the ejaculate [4,5]. Failure of appropriate testicular thermoregulation has been shown to diminish sperm quality increasing the likelihood of infertility in stallions [6]. Similar observations have been made in humans [7]. Elevated core body temperatures have also been shown in a prospective cohort study to be detrimental in the pregnant population being related to an increased risk of adverse pregnancy outcomes, including miscarriage, preterm birth, low birthweight, stillbirth, intra-uterine growth restriction and birth defects [8]. A comprehensive review of 23 research papers on the effects of ambient heat stress on pregnancy outcomes confirmed a definite association with miscarriages, premature birth, stillbirth, low birthweight, and congenital abnormalities [9]. A relationship between ambient temperature and preeclampsia syndrome and gestational hypertension has also been reported [10]. The mechanisms behind pregnancy-related heat stress injury have not been fully elucidated. However, it has been suggested that changes in the uteroplacental blood flow, inflammatory reactions, and dehydration consequences may have a contributory role [11].

Effects of ambient pollution on reproductive health

The climate change phenomenon over the last two centuries has been primarily driven by human activities related to emissions of greenhouse gases derived primarily from the burning of fossil fuels contributed to further by the clearance of forests which limits the carbon dioxide absorptive capacity. Fossil fuel combustion, aggravated by forest wildfires, not only contribute to gaseous CO₂ emissions, but also contribute to other health-detrimental air pollutants such as nitrogen dioxide, sulphur dioxide, carbon monoxide, and fine particulates. Besides affecting the long-term morbidity and mortality of people living in such air polluted environments, these air pollutants affect reproductive health by decreasing fertility and increasing adverse obstetric outcomes such as pregnancy loss, preterm birth, decreased birth weight, and other complications [12]. The relationship between low birth weight and air pollution exposure has also been described in multiple studies [12], while it has been estimated that about 39.7 % of all stillbirths worldwide can be casually linked to particulate air pollution [13]. More than 3.3 % of preterm births in the U.S.A. can be attributed to particulate air pollution [14]. Children exposed to gaseous and particulate air pollution in utero have been shown to have thinner brain cortices, impaired inhibitory control, and cognitive impairment, and autism spectrum disorder [15].

Other environmental pollutants have also been shown to have an adverse effect on reproductive health. Convenience and cost has generated the widespread use and exponential production of polyethylene (PE), polyvinyl chloride (PVC), polystyrene (PS) and other related products. Plastic production reached 348 million tons by 2017 and is expected to have increased ten-fold by 2025. The accumulated plastic waste reservoir has given rise to the phenomenon of microplastic [5 mm – 100 nm diameter] and nanoplastic [<100 nm diameter] pollution. Acting alone or as carriers to other environmental contaminants, these compounds breach the human defence mechanisms adversely affecting human reproductive health by disturbing germ cell acting as environmental endocrine-disrupting chemicals (EEDCs)

resulting in spermatogenic dysfunction and oocyte maturation leading to deleterious effects on male and female reproductive function. The identification of microplastics and nanoplastics in the human placenta and evidence of their placental translocation to the fetus raise the possibility that there may be direct consequences to fetal development [16].

Other environmental pollutants of concern vis-a-vie human reproduction include heavy metal exposure acting at genetic, epigenetic, and biochemical levels. Heavy metal exposure have been shown to have an impact on female reproduction leading to infertility, adverse obstetric outcomes such as early fetal loss, preterm deliveries and stillbirths, and further contribute towards risk of oestrogen-dependent neoplasia leading to breast and endometrial malignancy [17]. Heavy metal exposure has also been shown to adversely effect the male reproductive capacity potentially as endocrine disruptors affecting sperm quality thus predisposing to male infertility [18]. Other environmental Endocrine Disrupting Chemicals (EDC), such as phthalates, Bisphenol A, polychlorinated biphenyls, and pesticides, through their oestrogenic properties, have been linked to a variety of reproduction disorders, including female and male infertility [19] (See Fig. 1).

Alterations to the disease spectrum due to climate change

With changes in ambient temperature and climate the ecological profile of a region is expected to change potentially enabling the introduction of arthropod vectors, such as a mosquito, flea, and tick, with the potential to transmit human pathogens to areas where these infections were not previously endemic. The spread of these vectors is further enabled through the modern process of global travel. Vectors of particular concern to pregnant women and their foetuses include those enabling the transmission of West Nile, chikungunya, dengue, and Zika viruses, as well as malaria and tick-borne illnesses. The potential fetal and maternal consequences of these infections are dependent upon the infectious aetiology ranging from an increased risk of early and late foetal losses, preterm delivery, low birth weight and potential malformations [20] (See Fig. 2.).

The impact of reproductive medicine, obstetrics and gynaecology on environmental pollution

Climate change has now reached a stage that active measures need to be taken to reverse the process. Now it has already led globally to adverse impacts, losses and (irreversible) damage to nature and (the health of) people. It also affects public health and more specifically reproductive health. The carbon footprint of health care provision, including reproductive health care, obstetrics and gynaecology is significant. Because of this significance and ironically its negative effect on health, health care carbon footprint needs a transition.

Overpopulation, population growth and European lifestyle

Increasing population is the basis for increasing global warming and climate change. Having one fewer child has the highest impact on saving of emissions: 60 tons of CO₂ emission per child per year [21]. However, the lifestyle of high-income countries attributes much more to climate change when compared to the lifestyle of low- and middle-income countries. Low-income countries, despite overpopulation or population growth, are accountable for just a small share of the worldwide emission. European countries, therefore, contribute significantly to the current and to ongoing climate change [22–24]. There are a number of personal initiatives that can and must be taken to reduce CO₂ emissions [Fig. 3]. But, the significant role in reducing CO₂ emissions by simply reducing family size by one child through contraception use cannot be ignored [21], especially in those countries or regions where the fertility rate is in marked excess of population sustainability levels. While about two-thirds of the world's population today lives in a country with an unsustainable fertility rate (>2.1 births per woman over a lifetime),

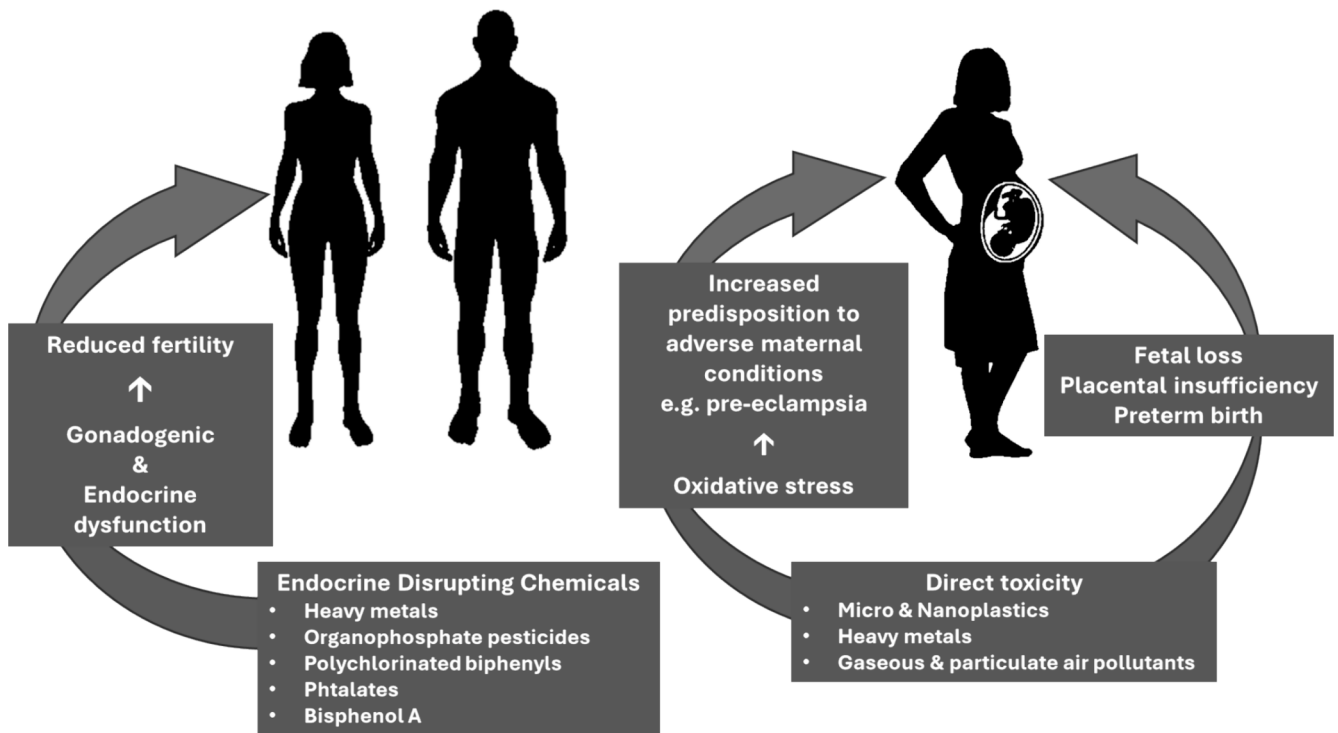


Fig. 1. Adverse reproductive effects of environmental pollution.

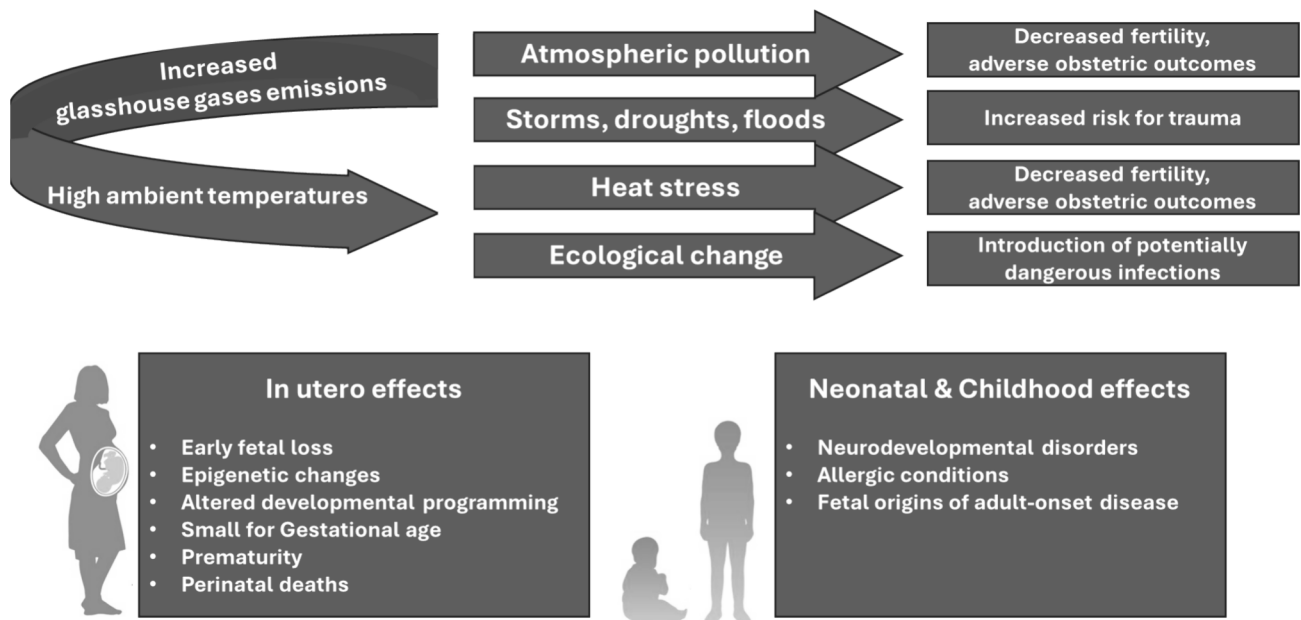


Fig. 2. Adverse reproductive effects of Climate Change.

projected population trends suggest that the world’s population will continue to grow to reach around 8.5 billion in 2030 and 9.7 billion by 2050. The average global fertility rate today is estimated to stand at about 2.3 births per woman but is projected to decrease to the 2.1 level by 2050 [25].

Similarly, breastfeeding initiatives can also make significant contributions to help reduce the reproductive health carbon imprint contribution. Besides the effects on the environment related to land use and biodiversity losses, the production of commercial milk formula generates around 11–14 kg of greenhouse gases per 1 kg of commercial

formulae milk produced. The promotion and support provided for breastfeeding initiatives for as long as possible would definitely help to mitigate and to offset the environmental carbon imprint [26].

Health care emissions

Health care in Europe is responsible for a significant part of the carbon footprint causing climate change. In 2014, the healthcare services in the Netherlands, Belgium, Austria, Slovakia, Germany, Ireland and United Kingdom contributed 6 % or more to their national carbon

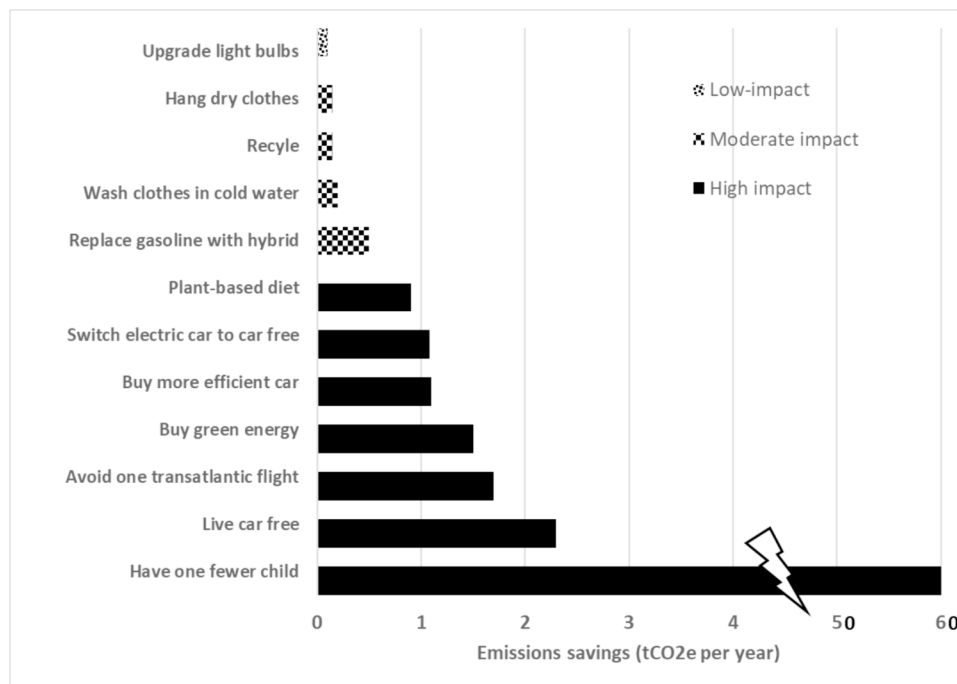


Fig. 3. CO₂ Emission savings from individual actions (modified from Wynes & Nicholas, 2017 [21]).

footprint. The annual health care carbon footprint per capita for these countries was 0,6 tons or more. Luxembourg stands out with a health-care carbon footprint of more than 1,2 tons of CO₂ emission per capita annually [23].

Operating Room [OR] emissions

Operation theatres are the most energy consuming and carbon-emitting localities within hospitals. The 24/7 lighting, ventilation, air-conditioning and heating systems within the OR account for 40 % of the overall healthcare emissions of the whole hospital. Furthermore, anaesthetic gasses released into the OR environment are themselves potent greenhouse gasses. Besides the effects on the carbon footprint, there are also considerations relating to the disposal of clinical waste such as packaging material and disposables. It has been estimated that operation rooms produce 50–70 % of all clinical waste in hospitals [27–29]. The carbon footprint and clinical waste production is further dependent on the type of surgery undertaken. For example, in respect to hysterectomy procedures, laparoscopic or robotic surgery generates nearly twice as much non-reusable waste [mean 23.7–26.6 lbs respectively] compared to vaginal or abdominal procedures [mean 9.9–15.6 lbs respectively] [21,30,31]. Similar observations can be made in regards to other interventions gynaecologists and obstetricians are dealing with.

For example caesarean section (31.21 kgCO₂e per caesarean section) compared to vaginal delivery (9.44 kgCO₂e per hospital delivery, 5.54 kgCO₂e per home delivery) has a significantly higher carbon footprint, unless Entonox is used as pain medication during vaginal delivery. Entonox is a major contributor due to extreme high emissions (246.73 kgCO₂e per vaginal delivery) [32,33]. Breastfeeding has proven environmental benefits compared to formula feeding, support for breastfeeding and its benefits contribute to long-term health and well-being of infants and mothers [34]. Finally, life-cycle assessment of acrylic disposable specula shows increased greenhouse gas emissions compared to reusable specula without significant difference in utility. This is explained by the material production and manufacturing of the acrylic disposable specula, as well as its contribution to waste [35]. This also applies for other disposables, if reusables are available.

There is no doubt whatsoever that climate change has taken a rollercoaster ride that will continue to accelerate unless measures are taken to control the present freefall. The contributors and the effects of climate change have definite adverse consequences of human reproductive health with lowered fertility and adverse obstetric outcomes. On the other hand, the reproductive healthcare providers also contribute significantly to the climate change process especially in high income countries. If we wish the climate change freefall to slow down, we must all start to assume responsibility and assume practices that are useful in reducing our personal and the specialty's carbon imprint.

European Board and College of Obstetrics and Gynaecology advocates that we must become constantly aware of all aspects of the carbon footprint of reproductive health care and implement interventions to increase sustainability and reduce the carbon footprint in obstetrics and gynaecology departments and in the supporting operation room. From the environmental point of view, we should consider the environmental impact of our actions/interventions and the choice of instruments in relation to its medical benefits, and we should not deal with family planning in a conservative manner.

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This paper was approved by the EBCOG Standing Committee on Standards of Care and Position Statements and the Executive Board of the EBCOG.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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