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SPECIAL COMMUNICATION

International Federation of Gynecology and Obstetrics opinion on reproductive health impacts of exposure to toxic environmental chemicals☆

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ABSTRACT

Exposure to toxic environmental chemicals during pregnancy and breastfeeding is ubiquitous and is a threat to healthy human reproduction. There are tens of thousands of chemicals in global commerce, and even small exposures to toxic chemicals during pregnancy can trigger adverse health consequences. Exposure to toxic environmental chemicals and related health outcomes are inequitably distributed within and between countries; universally, the consequences of exposure are disproportionately borne by people with low incomes. Discrimination, other social factors, economic factors, and occupation impact risk of exposure and harm. Documented links between prenatal exposure to environmental chemicals and adverse health outcomes span the life course and include impacts on fertility and pregnancy, neurodevelopment, and cancer. The global health and economic burden related to toxic environmental chemicals is in excess of millions of deaths and billions of dollars every year. On the basis of accumulating robust evidence of exposures and adverse health impacts related to toxic environmental chemicals, the International Federation of Gynecology and Obstetrics (FIGO) joins other leading reproductive health professional societies in calling for timely action to prevent harm. FIGO recommends that reproductive and other health professionals advocate for policies to prevent exposure to toxic environmental chemicals, work to ensure a healthy food system for all, make environmental health part of health care, and champion environmental justice.

1. Introduction

Widespread exposure to toxic environmental chemicals threatens healthy human reproduction. Industrial chemicals are used and discarded in every aspect of daily life and are ubiquitous in food, water, air, and consumer products. Exposure to environmental chemicals and metals permeates all parts of life across the globe. Toxic chemicals enter the environment through food and energy production, industrial emissions and accidents, waste, transportation, and the making, use, and disposal of consumer and personal care products.

For example, the industrialized food system is a major contributor to the introduction of toxic chemicals—from pesticides to plastics—into the environment [1]. Food is also a major pathway of exposure to environmental chemicals from human activities unrelated to agriculture [1]. Mercury pollution, primarily from the burning of coal, has far-reaching effects across the planet, including remote ecosystems [2]. Approximately 3 billion people in low-income countries are exposed to indoor air pollution from cooking and heating their homes using open fires and simple stoves that burn biomass (e.g. wood, animal dung, and

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crop waste) and coal [3]. Furthermore, in 2010, more than 8.6 million people were at risk of exposure to industrial pollutants at 373 toxic waste sites in India, Indonesia, and the Philippines alone [4].

World chemical manufacturing has grown rapidly over the past 40 years [5,6], with production projected to increase by 3.4% annually until 2030 [6]. There are now 70 000–100 000 chemicals in global commerce; approximately 4800 "high-production-volume chemicals" constitute the vast majority in global production [6,7]. Global pesticide use in agriculture reached 2.4 billion kg in 2007 [8]. In 2012, 9.5 trillion pounds (4.31 trillion kg) of industrial chemicals were manufactured in or imported into the USA [9]—equivalent to more than 30 000 pounds (13 000 kg) for every American.

The geography of chemical production is shifting away from high-income countries and toward low-income countries. By 2020, it is anticipated that low-income countries will lead the world in growth rate for high-volume chemicals [5,10]. The Organisation for Economic Co-operation and Development's outlook for environmental trends to 2030 identifies hazardous chemicals and waste as a "red-light" issue—i.e. not well managed, in a bad or worsening state, and requiring urgent attention [6].

2. Vulnerable people, communities, and populations

The potential health impact of a low-dose exposure to a toxic chemical is not the same for everyone. Communities as well as individuals vary in their vulnerability and in their risk for exposure. In addition to the timing and amount of exposure, risk depends on whether a person or population is in good or poor health, the presence or absence of other environmental chemical exposures and other stressors, and on other factors such as sex and genes [11,12]. In recognition of the fact that some are more vulnerable to toxic chemicals than others, the US National Academy of Sciences has concluded that, in the absence of evidence to the contrary, any level of exposure should be assumed to be potentially harmful—i.e. that there is no "safe dose" [11].

Exposure to toxic environmental chemicals and related health outcomes are inequitably distributed among populations within countries as well as between countries. For example, there is a higher burden of toxic exposures and resulting adverse health outcomes among Indigenous peoples in Canada, the USA, and other countries [13,14]. Poverty and exposure to toxic chemicals are tightly interwoven, and the nature of the risks and hazards of toxic chemicals vary by a country's level of development [15]. For instance, the rate of lower respiratory infections attributable to environmental causes is more than twice as high among low-income countries (42%) than among high-income countries (20%) [16]. Moreover, at every stage of development, the consequences of exposure to toxic chemicals—including morbidity and mortality, loss of family income and productivity, and environmental degradation—are disproportionately borne by people with low incomes [15].

Commerce and trade agreements influence the production and transfer of toxic chemicals within and across borders [17,18]. Occupational disparities also impact risk. For example, women and men exposed in the workplace to solvents, formaldehyde, ethylene oxide, anesthetic gases, pesticides, antineoplastic drugs, or to metals are at high risk for adverse reproductive health outcomes [19,20]. Racism, discrimination, and other social factors that can increase stress also influence exposures and associated health outcomes [21–23].

Preconception and prenatal exposure to toxic chemicals is a critical issue for both women and men of childbearing age. Women and men of reproductive age can encounter toxic chemicals at home, in the community, and in the workplace. Chemicals get into the body through breathing, eating, drinking, and/or penetration of the skin. Chemicals in pregnant women can also cross the placenta. For certain chemicals, such as methyl mercury, the levels in the fetus can be greater than those in the mother [24]. Furthermore, toxic chemicals can enter breastmilk after delivery: persistent organic pollutants and metals are found in the breastmilk of women around the world [25,26]. Once toxic chemicals enter the body, the reproductive health impacts can be many, can be varied, and can manifest across the lifespan of individuals and future generations.

3. Nature and extent of prenatal and preconception exposure to toxic environmental chemicals

A wide body of scientific evidence shows that the in utero environment is a critical bridge to future health outcomes [27]. Susceptibility to potential health impacts of toxic environmental chemicals may be heightened when exposure occurs during "critical" and "sensitive" periods of development, such as during pregnancy, childhood, and adolescence [28–32]. Although exposure to toxic chemicals at any point in life can be potentially harmful, there are time-specific vulnerable windows of human development when environmental factors, including nutrition, toxic chemicals, and other stressors, can dramatically alter developmental programming signals [29,33]. For example, prenatal exposure to lead, methyl mercury, or the pesticide chlorpyrifos interferes with one or more critical periods of human development leading to developmental neurotoxicity [34]. Consequently, even small exposures during a window of vulnerability can trigger adverse health consequences that can manifest across the life span of individuals and generations [29,31,35,36].

Exposure to toxic chemicals during pregnancy and lactation is ubiquitous. Research based on representative sampling of the population at large [37] has documented that virtually every pregnant woman in the USA has at least 43 different environmental chemicals in her body. Persistent organic pollutants are found in pregnant and lactating women across the globe [25,38,39]. A report by the US National Cancer Institute found that "to a disturbing extent babies are born 'pre-polluted'" [40].

4. Health impacts of preconception and prenatal exposure to toxic environmental chemicals

A key adverse health impact of ubiquitous exposure to environmental chemicals is disruption of hormones that regulate healthy human reproduction and development [41]. The potential for delayed onset of diseases due to prenatal exposure to hormonally active exogenous chemicals is firmly established by studies of the daughters and sons of pregnant women who took the drug diethylstilbestrol, a potent synthetic estrogen [42,43]. Although the mothers who took diethylstilbestrol seemed healthy, the drug caused a wide range of health impacts that became apparent only decades after the initial exposure, including clear cell adenocarcinoma of the vagina and cervix, structural reproductive tract anomalies, infertility, poor pregnancy outcomes, and breast cancer among prenatally exposed daughters [44], and hypospadias among prenatally exposed sons [45–47]. Similar relationships between environmental exposures incurred during pregnancy and adverse health impacts in later life have been documented in the field of human nutrition and in studies of wildlife [41,48–50].

Rates of non-communicable diseases (NCDs) such as cancer, cardiovascular disease, chronic respiratory disease, and diabetes are increasing, and the high rate of NCDs seen in high-income countries is now also emerging as a health crisis among middle- and low-income countries [51,52]. The global rise in the rate of NCDs encompasses increases in diseases and conditions related to the endocrine system—e.g. low semen quality, genital malformations, preterm birth and low birth weight, neurobehavioral disorders associated with thyroid disruption, endocrine-related cancers, early onset of breast development in young girls, and type 2 diabetes [41]. These trends have occurred in a timeframe inconsistent with a much slower pace of changes in the human genome, indicating that the environment has shaped these disease patterns [53].

The 2012 WHO/United Nations Environment Programme State of the Science on Endocrine Disrupting Chemicals states that "[c]lose to 800 environmental chemicals are known or suspected to be capable of interfering with hormone receptors, hormone synthesis, or hormone