Environmental influence on reproductive health

R.V. Bhatt

Chief Department of Obstetrics and Gynecology, BD Amin General Hospital, Baroda, India

Abstract

A rise in industrialization and the consequent environmental pollution, an increase in the use of synthetic chemicals and repeated exposure to hazardous compounds at the workplace and at home adversely affects reproductive health. Biohazardous compounds, some of which act as endocrine disrupters, are being increasingly implicated in infertility, menstrual irregularities, spontaneous abortions, birth defects, endometriosis and breast cancer. In some cases, women are at a greater risk than men, especially with the rise in environmental estrogens. Only a fraction of these chemicals have been adequately examined for toxicity and for synergistic effects due to multiple exposures. There is a need for a greater awareness and vigilance of the effects of environmental pollution on reproductive health. © 2000 International Federation of Gynecology and Obstetrics.

Keywords: Environment; Chemicals; Reproduction; Infertility; Gynecological cancers; Fetal malformation; Occupational hazards

1. Introduction

The health status of an individual is determined by the interplay of two factors — the internal environment of the body and the surrounding external environment. Clean air, potable water and a toxin-free diet goes a long way in ensuring good health. Unfortunately, the air we breathe, the water we drink and the food we eat are becoming increasingly polluted as more industries are built and more chemicals are used in agriculture to meet the growing needs of society. As we become increasingly dependent on technology, development demands its pound of flesh in health. Developing countries are especially vulnerable. In the hurry to globalize, they are industrializing very rapidly at the cost of the environment. Though many developing countries have formulated laws to prevent industrial pollution, the laws are violated by industries with impunity as they continue to dump industrial waste. The developed countries are more conscious about environmental pollution and have made strict laws to prevent pollution. Unfortunately, many of their hazardous industries are being shifted to and their hazardous wastes are being dumped in developing countries. David Nelson, an expert in US Environmental Protection Agency calls it ‘Industrial neo-colonialism’ [1].
Until a decade ago, obstetricians were not very aware of the impact of the environment on reproductive health. They were too engrossed in managing problems of infertility, abortions, obstetric hemorrhages, low birth weight babies and malformed babies on an individual basis. They did not realize that some of the obstetric and gynecological problems they were dealing with were the result of environmental influences.

The modern obstetrician is now aware of the role of environmental factors on the reproductive process, directly or indirectly. Water pollution can cause dysentery, typhoid, viral hepatitis, etc., which, in turn, can result in preterm birth and low birth weight babies. Occupational pulmonary diseases such as asbestosis or silicosis can also adversely affect reproductive health.

Environmental issues are assuming new importance as more and more pregnant women and children are being exposed to increasingly polluted environments. The wave of industrialization, consumer oriented life styles, abuse of pesticides, disinfectants and insecticides are responsible for disturbance in the ecological balance (Fig. 1). Furthermore, the number of women working in hazardous industries is on the increase. Some industries are dealing with hazardous substances like mercury, lead, arsenic and organic solvents. Pregnant women working in such industries are at risk of an adverse obstetric outcome.

According to data from the National Exposure Registry (USA) of the Agency for Toxic Substances and Disease Registry (ATSDR), females exposed to certain hazardous substances report more adverse health outcomes than national norms, and in some cases more than similarly exposed males. The registry currently consists of subregistries for benzene, trichloroethylene (TCE), trichloroethane (TCA), and dioxin. The purpose of the registry is to assess the potential long-term health impact on the general population of exposures to environmental hazards, such as those at Superfund sites. Female and male registrants of at least one subregistry have reported significantly more anemia and other blood disorders, skin rashes, and strokes compared to national norms provided by the National Health Interview Survey. Registrants also reported a greater amount of diabetes, kidney and liver problems, and urinary tract disorders, but rates for females were typically greater than those for males exposed to the same substances. The data indicate that the adverse health outcomes experienced by these women might be associated with exposure to low-level hazardous substances over extended periods [2].

Within occupational/environmental medicine, the women’s health problems of greatest concern in terms of prevalence or severity are those of reproductive effects of workplace exposures. The entire reproductive cycle may be at risk for exposures to physical and chemical agents in the workplace. Some exposures may also be significant in the home and general environment. Issues of significance include [3]:

- infertility and hypofertility;
- spontaneous abortion, including early undetectable abortion;
- teratogenesis and congenital malformation;
- mutagenesis and hereditable defects;
- cancer in offspring (e.g. DES use and cancer); and
- genital and breast cancer in occupational exposures.

2. Substances of concern

Many specific synthetic chemicals or metals are
known to harm human reproduction or development. Lead, for example, that is used in printing, painting and battery industries is known to cross the placental barrier as early as in the 12th week of gestation and can potentially disrupt brain development in the fetus. Hamilton concluded that wives of men working in lead-based industries have a higher incidence of abortion, preterm labor and still births as compared to the general population [4]. Nagako reported a higher incidence of abortion among female workers handling lead [5]. Mercury, which is present in many fungicides and is often handled by women, has been shown in experiments to disrupt embryogenesis in laboratory mice and rats [6]. Solvent exposures are associated with spontaneous abortions in female workers. Several specific solvents have additional adverse effects — glycol ethers and epichlorohydrin damage male reproductive function, and toluene causes birth defects at high levels of maternal exposure. Workers exposed to mixtures of pesticides are at an increased risk of spontaneous abortion and birth defects in offspring. Some pesticides, e.g. the fumigant, ethylene oxide, used to sterilize medical equipment, or the fungicide, benomyl, and herbicide, cyanazine, used in agriculture, are identifiable as particularly associated with adverse reproductive outcomes. While the scientific evidence is weaker and still emerging, many other chemicals may also adversely impact human reproduction. Suspects include cadmium, manganese, several solvents including xylene, styrene, and perchloroethylene, and numerous pesticides and plasticizers [7]. Investigators also reported an increased incidence of abortion, IUGR, still births and increased perinatal mortality amongst women in Bhopal, India, who were exposed to the industrial methyl isocyanate (MIC) gas leak [8,9].

It has been shown that several chemicals present in environmental pollution have the capacity to act as hormones. When these 'environmental hormones' are taken into the body through air pollution, they can mimic the effects of the body's natural hormones and disrupt a number of important biological processes. Environmental pollutants that can mimic the hormone estrogen include DDT, DDE, kepone, heptachlor, PCBs, dioxin, and breakdown products of detergents. Many of these compounds can be carried for long distances through air pollution and then deposited into soil and water, and eventually into the food chain [10].

Although not an environmental estrogen, dioxin, one of the most toxic chemicals in the environment, is capable of blocking estrogen action, lowering levels of androgens (male hormones), and affecting the amount of thyroid hormones produced. It can also affect insulin levels and the amount of glucocorticoid secreted by the adrenals. It has also been implicated as a cause for endometriosis. Exposure of pregnant animals to very low levels of dioxin can damage the reproductive system of the offspring, resulting in a decreased sperm count and altered mating behavior. Many pollutants mimic estrogen and may be responsible for breast and uterine tumors [10].

Theodora Colborn, a zoologist from USA, suggested the term ‘endocrine disrupters’ for substances that interfere with or mimic the action of hormones and then upset the normal growth, behavior and reproduction. Endocrine disrupters may have transient effect on adults but these effects can be permanent in fetus’ causing various malformations. They can throw off the system by sending wrong signals or blocking the right signals. Many chemicals like dioxins, PCB, dicofol and other DDT-related compounds are identified as endocrine disrupters.

Animal testing reveals that a single dose of a tiny amount of dioxin administered during a critical ‘window of vulnerability’ in pregnancy can lead to life-long health effects in offspring. Men exposed to Agent Orange, a herbicide containing dioxin, are more likely to father children with birth defects. In addition, maternal exposure to PCBs seems to result in developmental delays in children. Dioxin and PCBs are examples of chemicals, which appear to derail human reproduction and development by interfering with hormones. Other chemicals, which may also be endocrine disrupters in humans, are commonly found in consumer products such as plastics, paints, detergents, cosmetics, and pesticides. While the full significance of some of these newly recognized or suspected reproductive and devel-
Developmental toxins is not yet clear, there is reason for concern about a wide range of chemicals and their potential effects on human health [7].

Some effects of certain estrogenic compounds on the animal population have been well known for some time. Two well-known cases are the eggshell thinning and cracking that led to the broad population decline of American bald eagles, and the health, fertility, and reproductive abnormalities of women exposed in utero to diethylstilbestrol (DES) a synthetic estrogen prescribed between 1948 and 1971 (when its use was banned) to prevent spontaneous abortions [11].

Only recently, however, have researchers begun to realize how many compounds common in the environment are estrogenic, much less the breadth of their potential effects. Theo Colborn of the World Wildlife Fund and colleagues list 45 chemicals or classes of chemicals that have been reported to disrupt the reproductive system or hormone system. Among their number are herbicides, fungicides, insecticides, nematocides, and such industrial chemicals and byproducts as metals, polychlorinated biphenyls, dioxin, styrenes, and nonylphenols. Some wildlife biologists believe that endocrine-disrupting chemicals are placing many wildlife populations at risk. Exposure to environmental contaminants has been linked to documented problems in wildlife that include the following [11]:

- thyroid dysfunction in birds and fish;
- decreased fertility in birds, fish, shellfish, and mammals;
- decreased hatching success in birds, turtles, and fish;
- gross birth deformities in birds, fish, and turtles;
- male fish, birds, and mammals that are feminized;
- female fish, birds, and mammals that are masculinized; and
- compromised immune systems in birds and mammals.

Many of these effects are manifest in species living in or near the Great Lakes. These lakes contain many synthetic chemicals, including byproducts of chemical production (such as PCBs) and pesticides (including some now restricted or banned, such as DDT). In herring gull embryos and newly hatched chicks from Lake Ontario, some males have oviducts and gonads resembling ovaries and the oviductal system in female birds are developing abnormally. Two-to-four-year-old salmon show 100% prevalence of thyroid enlargement. Bird species that feed on Great Lakes fish show behavior changes, failed reproduction, and early mortality in offspring. Other large drainage basins and areas where pollution exposure is high also exhibit effects tied to exposure to environmental estrogens. In fact, some of the most compelling evidence that wildlife responds to exposure to pollutants was learned from Lake Apopka, Florida’s fourth largest water body. There, researchers from the University of Florida in Gainesville surveying the hatching rates of alligators from various lakes found that between 80 and 95% of alligator eggs from Lake Apopka failed to hatch, compared to 20–30% for other lakes. The mortality rate for those that did hatch from Lake Apopka was at least 10 times the expected rate. Later examination showed that the female hatchlings had estrogen levels approximately twice as high as normal and the males had almost no testosterone [11].

Other abnormalities — the females had abnormal eggs and far too many, the males had what looked like ovaries, and juvenile male alligators had penises one-half to one-third the normal size — were tentatively tied to the effects of estrogenic chemicals. In this case, the lake was laced with the pesticide difocol, produced for years at the adjacent Tower Chemical Company. The difocol in the lake contained up to 15% DDT or DDE, an even more toxic product that forms as DDT breaks down. Spills occurred, including a major one in 1980, and the lake is now a Superfund site. Laboratory studies showed that normal eggs painted with estrogenic chemicals exhibited the same abnormalities as Lake Apopka’s alligators.

Such findings fuel researcher’s growing concern about the potential effects of environmental estrogens [11].
First, the effects are more often manifest in offspring, not in the exposed parent.

Second, the effects of exposure depend on the timing relative to the organism’s stage of development.

Third, the effects of exposure to endocrine-disrupting chemicals may be manifested in entirely different ways in the early embryo, fetus, and newborn than in organisms exposed only in adulthood.

Finally, because the effects of exposure are often delayed, they may not be fully expressed until the offspring of the exposed adult reaches maturity or even middle age. If so, the reproductive future for some species may be grim even if adults continue to breed and juveniles seem healthy.

3. Reproductive health effects

The evidence that environmental estrogens affect wildlife is strong. Evidence for similar risks to human beings is fragmentary, but also disquieting. Researchers are examining the possibility that, through subtle biochemical and physiological changes, these chemicals interfere with the development of people exposed prenatally or soon after birth. Estrogen mimics are extremely potent in part because unlike most natural estrogen they cross the placental barrier, exposing the fetus to greater than normal levels of hormone. These exposures can upset the delicate hormonal balances that determine everything from fertility to gender itself [11].

In men, some studies indicate that the estrogenic compounds affect the development of the Sertoli cells in the testicles. These cells secrete masculinizing hormones that regulate sperm production, the descent of the testicles, and the development of the urethra. Researchers in Europe and North America are studying a possible link between exposure to estrogen disruptors during key points in the development of reproductive organs and systems and the increasing incidence in some industrialized countries of prostate and testicular cancer, as well as lower sperm counts and sperm volume, undescended testes in newborn males (the incidence of which doubled in the UK between 1970 and 1987), and abnormalities of the urinary tract [11,12].

In women, researchers suspect that a 400% increase in ectopic pregnancies between 1970 and 1987 and an increase in female breast cancer between 1969 and 1986 in the USA may be the result of exposure to pesticides and other endocrine-disrupting chemicals. Women with breast cancer have higher blood levels of DDE than cancer-free women according to some studies. Breast cancer has increased at a rate of approximately 1% per year for the past 50 years. After years of unexplained, steady increases in breast cancer, public health researchers hypothesize that exposure to estrogenic compounds affects estrogen production and metabolism in a way that effectively increase lifetime exposure to estrogen. All known risk factors for breast cancer account for no more than 30% of cases. However, most of these risk factors — which include age at menarche, first full-term pregnancy, and menopause, total calorie intake, family medical history, and radiation exposure — are linked to total lifetime exposure to reproductive hormones. Only 5% of breast cancer cases are the inherited familial form. Researchers are looking for possible mechanisms by which artificial estrogens interact with breast-cancer susceptibility genes, fostering cancer. If the connection between environmental estrogens and breast cancer is proven, it may be possible to lessen the risk for this disease by reducing exposure to the chemicals [11,13].

Corbet et al. [14] have shown that birth defects occurred nearly three times more often in a study of 621 Michigan nurse anesthetists. A total of 16.4% of nurses practicing anesthesia during pregnancy had children with birth defects compared to only 5.7% of nurses not practicing anesthesia. Wyatt [15] report an increased risk of abortion, still births and fetal malformation among women anesthetists. It may be due to prolonged exposure to inhalation of anesthetic agents.

In recent times, microprocessors have brought video-display terminals into offices and homes. The ionizing radiation generated by video-display
consists of X-rays, the adverse reproductive effects are well known. However, X-rays emitted by cathode ray tube in the video-display terminal are entirely absorbed by the glass screen [16]. The scan of recent literature suggests that women working with video-display terminals are not at excess risk [17].

4. Establishing links

The hypothesis that environmental estrogens, many of which are only weakly estrogenic, may be affecting human health has stirred a lively debate among toxicologists. Controversial issues include whether animal studies can be extrapolated to human beings, whether people exposed to low levels of environmental estrogens may be at risk of fertility problems or cancer, and whether the whole topic simply has been blown out of proportion. The proportion of malformation caused by environmental factors is difficult to estimate as it is difficult to prove a link between a particular pollutant and birth defect.

5. Taking an environmental history

More than 70,000 synthetic chemicals and metals are currently in commercial use in the USA alone. The toxicity of most of these is unknown or incompletely studied. In humans, exposure to some may cause cancer, reproductive and developmental disorders, adverse neurological and immunological effects, or other injuries. Reproductive and developmental effects are of concern because of important consequences for couples attempting to conceive and because exposure to certain substances during critical periods of fetal or infant development may have lifelong and even intergenerational effects.

Occupational and environmental exposures may cause episodic, acute, or chronic illness, and inquiry should be a routine part of every history and physical exam. Important information can be obtained quickly. Routine questions should include information on [18]:

- Specific nature/duration of a patient’s current or past work and/or hobbies (daily or occasional exposures, including specific job classifications and substances present and/or handled at the workplace).
- Exposures to fumes, dust, or chemicals at work, home or in hobbies (brand or generic names of chemicals should be obtained; general chemical classes are often insufficient for understanding health risks).
- Occupation and hobbies of spouse, partner, children.
- Physical symptoms at work or during exposures.
- Levels of ventilation in work/hobby area.
- Results of any air monitoring at the workplace.
- Use of personal protective equipment: gloves, respirator, protective clothing.
- Hand-washing and/or shower facilities at work/how frequently used?
- Accidents or exposure incidents at work, home or in the community.
- Household chemical or pesticide use.

Data thus generated can go a long way in helping establish links between environmental health and reproductive problems.

6. Conclusion

In cases where etiologic determinants may be unknown or obscure, it is possible or likely occupational or environmental factors might play a role, though the significance may be difficult to establish. Many exposures may play an active or potential role in many conditions. On the other hand, it is also likely in many cases that occupational and environmental factors may be red herrings. Many supposed household exposures may fall into one of these categories. Many suspected links between women’s health problems and environmental exposures exist. Some, like the VDT
and spontaneous abortion issues, will not hold up under good scientific research — others may. These would include tobacco smoke, second-hand smoke, household exposures (i.e. radon, solvents and other chemicals), alcohol, and heavy metals. From the occupational and environmental medicine perspective, there are many priority research needs in the area of women’s health and environment.

Raising these issues through the media has, focussed both public and scientific attention on the rising levels of pollutants in the environment. All involved agree on the need for further study. Unfortunately, toxicological information is often incomplete. Animal testing usually looks at health effects using one chemical at a time. This strategy fails to provide information about interactive effects, which may occur with exposure to more than one chemical. Moreover, animal tests often fail to examine for subtle, delayed, or difficult-to-diagnose conditions. Epidemiological (human) studies are often limited by inaccurate exposure assessments and incomplete information about health outcomes. Further complicating matters, governments support for research and information analysis is scant and often non-existent, especially in developing countries. Corporate funding is filling the void, providing an opportunity for bias in study design and data interpretation. Without research and irrefutable evidence, interventional steps to prevent adverse events of environmental pollution on reproductive health cannot be taken. There needs to be a greater awareness and greater vigilance to this growing problem that will only grow in magnitude as we move into the 21st century.

References


[3] Women’s health and environment. Approved by Board of Directors of the American College of Occupational Medicine (ACOEM) on 27 April 1993 and submitted to Scientific Advisory Meeting III.


