Environment and Health: Not Only Cancer

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Abstract: The Hippocratic tradition emphasized environmental causes of diseases and the need for harmony between the individual and the natural environment as the right philosophy to maintain a good health status. Public awareness and scientific attention concerning environmental pollution is usually focused on the consequent increased risk of developing cancer. Air pollution has been recognized by the World Health Organization (WHO) to cause cardiovascular and respiratory diseases, as well as lung cancer, after acute/chronic exposure to fine particulates (PM$_{2.5}$ and PM$_{10}$) even at concentrations which are 50% lower than those accepted as legal limits in many developed countries. An increase of 10 µg/m$^3$ of PM$_{2.5}$ produces a +4%–6% of overall mortality, a +10% of cardiovascular disease prevalence (arhythmias, acute myocardial infarctions, and heart failure) and a +22% of lung cancer prevalence. In addition to these chronic effects, acute hospitalizations are also affected, especially among susceptible populations such as children and diabetic patients. Water and soil contamination also have an additional detrimental effect on people’s health. Other issues concerning environment contamination and human health include male/female fertility, metabolic and thyroid conditions, but also professional exposures resulting in occupational diseases. Moreover, in the perspective of “gender medicine”, different acute or chronic effects of environmental pollution should be specifically assessed both in men and in women. This special issue on “Environmental Diseases” is aimed at providing a global overview about different threats to human health possibly originating from environmental contamination.  

Keywords: environment and health; pollution; cancer; cardiovascular and respiratory diseases; metabolic diseases; thyroid dysfunctions; occupational exposures and diseases  

1. Introduction  

The 2013 European Environment Agency (EEA) “Air quality in Europe 2015 Report” [1] indicates that about 80% of people living in European cities are exposed to high concentrations of fine particulates (PM$_{2.5}$ and PM$_{10}$), known to have carcinogenic effects for humans (International Agency for Cancer Research, IARC position 2015) [2]. It is noteworthy that the 2005 World Health Organization (WHO) guidelines have recognized that PM$_{2.5}$ and PM$_{10}$ particulates cause negative effects on human health (in terms of cancers, respiratory, and cardiovascular diseases) even at concentrations which are 50% lower than that which is considered acceptable within the current European legal limits and environmental laws of Member States [3]. These WHO indications have been confirmed by the findings of large studies such as ESCAPE (European Study of Cohorts for Air Pollution Effects), which started in 2008 to evaluate long-term effects of air pollution on European citizens, as well as a large longitudinal study carried out on one million people living in Rome to assess the “weight” of PM$_{2.5}$ and NO$_2$ in the overall mortality registered in the last decade [4–6].
These studies have estimated that each increase of 10 µg/m³ of PM$_{2.5}$ results in an increase of 4%–6% of the overall mortality, a 10% increase of cardiovascular disease prevalence (arhythmias, acute myocardial infarctions, and heart failure), and up to 22% increase of lung cancer prevalence, as chronic effects [4,5]. Acute effects of air pollution (both in terms of mortality and hospital admissions) have been investigated by a MedParticles study, which confirmed the association between PM$_{10}$ and PM$_{2.5}$ particulate concentrations and hospitalizations due to respiratory diseases and asthma re-acuteizations in the general population, including diabetic patients and children [7].

In addition to cardiovascular or respiratory diseases and lung cancer resulting from air pollution, other issues concerning environmental contamination and human health include male/female fertility, metabolic and thyroid conditions, and also professional exposures resulting in occupational diseases. Despite all this, public awareness and scientific attention concerning environmental pollution is usually focused on the consequent increased risk of developing cancer. This special issue on “Environmental Diseases” is aimed at providing a global overview about different threats to human health originating from environmental contamination.

1.1. Air Pollution and Human Health: Increased Risk of Cancer, Cardiovascular and Respiratory Diseases

Reliable evidence is now available in the medical literature regarding the association between exposure to fine particulate (both acute and chronic) and human health. The “National Morbidity, Mortality, and Air Pollution Study” (NMMAPS) has assessed the negative effects of exposure to fine particulate (PM$_{10}$ and PM$_{2.5}$) on mortality due to cardiovascular and respiratory diseases by examining temporal series of the largest U.S. cities [8,9]. Negative effects on human health from short-term exposure to PM$_{2.5}$ were observed by Ostro et al. in a specific assessment involving nine cities in California, showing a clear association between an increase of 15 µg/m³ of PM$_{2.5}$ and mortality (+0.61% for overall causes; +0.70% for cardiovascular conditions; +2.05% for respiratory diseases) [10].

These results were confirmed in European settings by the APHEA/APHEA-2 studies (Air Pollution and Health, a European Approach, concerning the association between PM$_{10}$ and NO$_2$ short-term exposures and increases in overall mortality) [11,12], the MISA study (Italian Meta-Analysis on Short-Term Air pollution, involving 15 Italian cities with a total of 9.1 million inhabitants characterized for mortality due to cardiovascular and respiratory conditions) [13], the SISTI study (Italian Survey on Susceptibility to High Temperatures and Air Pollution, carried out in 9 cities) [14], and the EpiAir Project (a survey matching environmental and healthcare datasets concerning 300,000 people aged <35 years old, living in 10 Italian cities in the years 2001–2005) [15]. The acute exposure to hotspots of air pollutants such as fine particulates (PM$_{10}$), NO$_2$, and O$_3$ has been shown to increase hospital admissions for cardiac diseases and respiratory complaints, especially in sensitive subgroups (i.e., asthmatic patients) [16–18].

In a German study, women aged 50–59 years old living within 50 m from heavily trafficked roads (in the hypothesis of a long-term exposure) had a 70% higher probability of mortality as a consequence of cardiovascular or respiratory diseases than those living far away from urban traffic (odds ratio OR: 1.70; 95%CI 1.02–2.81) [19]. In a systematic review of European and American studies, the risk of developing cancer or cardiovascular/respiratory diseases following long term exposures to air pollution was found to be 6% higher for each increase of 10 µg/m³ in the atmospheric concentration of PM$_{2.5}$, with this result being independent of age, gender, and geographic area [20]. Similarly, a 16-year follow up carried out on 500,000 people living in U.S. urban areas has shown—per each increase of 10 µg/m³ of PM$_{2.5}$—an increase of 6%, 9%, and 14% in the overall mortality (all causes), lung cancer prevalence, and cardiopulmonary conditions, respectively [21].

A Dutch survey on 120,852 people showed similar increased risks concerning long term exposures to NO$_2$ (+5% in overall mortality and cardiopulmonary diseases, but a +20% increased risk of mortality due to of lung cancer after chronic exposure to air pollution originating from urban traffic) [22,23]. A recent 18-year follow-up carried out on German women has pointed out significant increases in the risk of mortality due to cardiopulmonary diseases and lung cancer as a consequence of minimally
increased levels of PM$_{10}$ atmospheric concentrations (7 µg/m$^3$) [24]. A specific association between PM$_{2.5}$ or NO$_2$ and an increased risk of mortality from cardiovascular diseases and pulmonary cancer has been highlighted also in a study carried out in Rome and another study involving 20 US cities [5,25]. Living in urban areas has been proven to be more frequently associated with the presence of mutagenic markers indicating an early biologic effect (sister chromatide exchange) or with asthma/respiratory conditions than living in sub-urban or rural areas [26,27]. Vineis et al. (European Prospective Investigation on Cancer and Nutrition, EPIC) have observed a significant association between chronic exposures to NO$_2$ (concentrations > 30 µg/m$^3$) and lung cancer (OR: 1.30; 95%CI 1.02–1.66) [28].

The same EPIC population has allowed sub-analyses that have confirmed the higher risk of traffic-exposed workers developing lung cancer [29]. Concerning professional exposures, a study of a cohort of 230,000 bus drivers showed that a significant increase of mortality due to cancer is present in workers exposed to traffic for 30 or more years [30]. Another population characterized by higher susceptibility—other than workers—is that of children, whom have been shown to suffer more than adults from asthma and other respiratory conditions when exposed to high concentrations of fine particulate and NO$_2$ (with these pollutants also being associated with increases in overall pediatric mortality rates) [31–44].

1.2. Effects on Human Health of Soil, Water, and Food Chain Contamination

The issue of potential effects of illegal toxic waste dumping has been addressed in several studies [45–51]. Increased cancer mortality rates (lung, liver, gastric, kidney, and bladder cancer) and clusters of malformations (at limb, cardiovascular, and urogenital systems) have been documented in some areas characterized by the widespread illegal practice of dumping toxic and urban waste [47]. While many illegal waste sites have been found to contain dangerous chemicals such as mineral oil, lead, mercury, aluminum residuals, arsenic, and tire residuals, even the presence of authorized urban waste dumping sites has been recently proposed for association with a higher risk of gastric cancer [52]. The scientific community is aware that persistent pollutants can contaminate the food chain leading to a bioaccumulation phenomenon in animals [53] and even in humans [54–65]. The presence of dioxin and polychlorobiphenyls PCBs have been documented in breast milk of young women in many industrialized countries, and this has been proposed as a potential reliable model for the assessment of people’s exposure to environmental contaminants. A systematic review on 50 studies of waste landfills and incinerators has found a relationship between the risk of congenital anomalies in people living in the proximity of special waste landfills [66]. Heavy industrial contamination resulting in the spread of arsenic, lead, mercury, nickel, cadmium, polycyclic aromatic hydrocarbons PAHs, and halogenated compounds has been indicated by many authors to be responsible for the excesses of mortality and morbidity of resident populations [67–82]. Evidence is also available concerning water and soil contamination due to the massive use of pesticides in intensive agriculture [83].

1.3. Effects of Endocrine Disrupting Chemicals on Cardiovascular System and Metabolism

Recent evidence supports a role of phthalates in the pathogenesis of atherosclerosis and hypertension. It is well known that phthalates are commonly found in several household products such as food packaging, furniture, and toys. Humans are exposed to phthalates through different means such as inhalation, ingestion, and dermal exposure [84]. Because of the abundance of plastic in our society, this exposure to phthalates is ubiquitous. The PIVUS study (Prospective Investigation of the Vasculature in Uppsala) demonstrated a significant inverse correlation between mono-ethylphthalate and both systolic blood pressure (SBP) and diastolic blood pressure (DBP) increases [85]. Phthalate metabolites were associated to SBP but none of these metabolites was related to DBP in the study by Trasande et al. [86]. A strong relationship between di-2-ethylhexyl phthalate and blood pressure was found in a subsample of US children aged 6–19 years who participated in the National Health and Nutrition Examination Survey between 2003 and 2008. For each log unit increase in di-2-ethylhexyl phthalate metabolites, a 0.041 SD unit increase in systolic BP z-score was
identified [86]. Monobenzylphthalate has been associated with increased DBP and increased risk of pregnancy-induced hypertensive diseases in 369 women of the Health Outcomes and Measures of the Environment study, a prospective birth cohort of low-risk pregnant women recruited between March 2003 and January 2006 [87]. In the study performed by Lind et al., mono-methyl phthalate was related to carotid plaques in an inverted U-shaped manner while mono-isobutyl phthalate and mono-methyl phthalate levels were associated to the echogenicity of the plaque [88]. The phthalate-related hypertension could be related to the increased plaque echogenicity and intima-media thickening and echogenicity that are more likely to happen in subjects exposed to phthalates [88].

By analyzing 2003–2004 National Health and Nutrition Examination Survey NHANES data, Lang et al. found that one standard deviation increase in urinary Bisphenol A concentration was associated with an increase in cardiovascular diseases such as coronary heart disease, myocardial infarction, and angina (OR 1.39, 95% CI 1.18–1.63) [89]. If Bisphenol A exposure is indeed associated with cardiovascular diseases, it would be a major public health problem since Bisphenol A exposure is ubiquitous. In fact, Bisphenol A-based polycarbonate plastics are used in plastic bottles, food containers, and optical disks, while epoxy resin-containing Bisphenol A is used in water pipe lining [90]. Bisphenol A has been associated with insulin resistance and it has also been suspected to modulate adiponectin and resistin gene expression in obese children, thus being involved in the pathophysiology of type 2 diabetes [91,92].

2. Conclusions

Developed countries and emerging economies need to take heed of the mounting evidence against pollution because even small reductions of environmental pollutants could confer substantial population health benefits. Moreover, in the perspective of “gender medicine”, different acute or chronic effects of environmental pollution should be specifically assessed both in men and in women as well as in children and other specifically susceptible populations.

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