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Air Pollution and Primordial Prevention of Chronic Non-Communicable Diseases

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1. Introduction

Air pollution is a global health issue with serious public health implications particularly for children. Studying the effects of environmental factors on the early stages of atherosclerosis can serve for future studies and offer strategies for primary prevention of chronic disease.

Usually respiratory effects of air pollutants are being considered, this chapter highlights the importance of non-respiratory health hazards from early life. In addition to short-term effects, exposure to criteria air pollutants from early life might be associated with low birth weight, increase in stress oxidative and endothelial dysfunction which in turn might have long-term effects on chronic non-communicable diseases.

The independent association of air pollutants with surrogate markers of endothelial dysfunction and a possible pro-coagulant state is underscored. Similar independent associations are documented for air pollutants and hematologic parameters as well as a possible pro-inflammatory state. The presence of these associations with PM₁₀ (larger than PM_{2.5} usually considered as harmful) and in a moderate air quality (which is commonly considered with few or no health effect for the general population) highlights the need to re-examine environmental health policies and standards for the pediatric age group.

Atherosclerosis begins in early life, and the role of platelets is well-documented from its early stages. The concern of medical literature on atherosclerotic cardiovascular diseases is mostly about some specific inflammatory diseases, and the role of environmental factors, as air pollution is overlooked in many studies. Many studies have documented that disturbance of the inflammatory and the coagulation systems after exposure to air pollution might be a factor in endothelial dysfunction and the progression of cardiovascular diseases. The increase in platelets number and aggregation may be a surrogate marker of early hematologic and hemostatic changes due to air pollutants. The systemic pro-inflammatory and pro-coagulant response to inhalation of fine and ultrafine particulate matters suggest a role for platelet activation in this process.

Facilities should be provided for families to become aware of the quality of the air year-round and to check daily air-quality levels and air-pollution forecasts by mass media, local weather reports and other available public information sources. This is especially important for smog levels during hot weather. Protective measures should be taken into account for children and pregnant women to reduce their exposure to air pollutants, e.g. children and pregnant women should avoid congested streets and rush hour traffic, moreover families

should try to limit the amount of time their child spends outdoors in vigorous activity if the air quality is unhealthy.

In view of the emerging epidemic of chronic disease in low- and middle- income countries, the vicious cycle of rapid urbanization in such communities resulting in increasing levels of air pollution and its consequent effects on chronic diseases, as well as the limited financial resources of these countries for planning effective air pollution control programs, public health and regulatory policies for air quality protection should be integrated into the main priorities of primary health care system and into the educational curriculum of health professionals.

2. Health hazards of air pollution

Air pollutants have many adverse effects on various body organs with short- and long-term health consequences. A summary of the health hazards of air pollution is presented in Table 1.

3. Susceptibility of children health to air pollutants

Infants and children are among the most susceptible age groups for air pollutants, because they may have greater exposure than adults to air pollutants, this is especially important during summer time with highest smog levels; they have higher respiratory rates than adults, and consequently higher exposure to air pollutants. The mouth breathing of infants and children bypass the filtering effect of the nose, and they would inhale higher levels of pollutants than adults. Children generally spend significantly more time outdoors than adults. In addition, the children's immune systems and developing organs are still immature (Kim, 2004).

4. Long-term effects of air pollutants on children's health

Air pollutants have various adverse effects from early life, some of the most important harmful effects are perinatal disorders, infant mortality, respiratory disorders, allergy, malignancies, cardiovascular disorders, increase in stress oxidative, endothelial dysfunction, mental disorders and vitamin D deficiency. However, till now most focus has been on the short-term respiratory effects of air pollution on children's health. In this chapter, we highlight the wide range of hazards of air pollution from early life, and their possible implication on chronic non-communicable diseases of adulthood.

The late-onset effects of air pollution in early life may be related to many chronic diseases later in life. Most chronic non-communicable diseases originate from early life, however studies about the relationship of environmental factors, notably air pollution, with risk factors of chronic diseases are scarce in children and adolescents.

5. Exposure to air pollutants in early life and chronic diseases in adulthood

Many studies have documented the effects of criteria air pollutants on low birth weight and or prematurity. There is a growing body of evidence about the association of intrauterine growth retardation and low birth weight with increased risk of chronic non-communicable diseases such as obesity, hypertension and cardiovascular disease later in life (Sinclair et al., 2007). Furthermore, prematurity can be associated with higher risk of chronic diseases (Evensen et al., 2008).

| Reference | Location | Population studied | Aims | Findings |
|-------------------------|--|--|---|--|
| Mengersen et al. (2011) | Lao PDR (one of the least developed countries in Southeast Asia) | the first study that investigated indoor air quality and its impact within residential dwellings in Lao PDR | study on the association between measured air pollutants and the respiratory health of resident women and children | There was a strong and consistent association between NO(2) and CO for health outcomes for both women and children. Dwellings with higher mean concentrations of the odds of almost all of the health outcomes. Concentrations of NO(2) are associated with lower PEFV. |
| Kaplan (2010) | Review | - | This review focuses on the contribution of solid fuels to indoor air pollution . | The incomplete combustion of solid fuels produces byproducts with well-known health effects, increasing the risk of many adverse health conditions are acute respiratory infections, obstructive pulmonary disease, lung cancer, cataracts and blindness. In addition, adverse pregnancy outcomes. |
| Dennekamp &Carey (2010) | USA | | | Health effects : lung (↓function, ↓airway reactivity , Exacerbation of asthma and Exacerbation of cardiovascular disease) |
| Cao et al., (2010) | China | 70,947 middle-aged men and women in the China National Hypertension Survey and its follow-up study. Baseline data were obtained in 1991 and follow-up evaluation was conducted in 1999 and 2000. | association of air pollution with mortality using proportional hazards regression model. | We found significant associations between air pollution and mortality from cardiovascular disease and cancer. Each 10µg/m(3) elevation in PM(10) was associated with a 0.9% (95% CI: 0.2%, 2.3%), 4.0% (95% CI: 1.3%, 6.7%), and 2.3% (95% CI: 0.1%, 4.5%) increase in cardiovascular mortality, respectively. |
| Nandi &Gorain (2010) | India | population of Durgapur town | detect the effect of pollution on human health. Two parameters, i.e., modes of transport and travelling time were chosen for this analysis. | There is pollution effect on human health. The results are of significance. Only heada paper. |

| Reference | Location | Population studied | Aims | Findings |
|---------------------------|--------------------------|---|--|---|
| Nandasena et al., (2010) | Sri Lanka | PUBMED and Medline databases, local journals and conference. | PUBMED and Medline databases, local journals and conference proceedings were searched for epidemiologic studies pertaining to air pollution and health effects in Sri Lanka | Sixteen studies investigated to ambient or indoor air po outcomes ranging from res weight and lung cancers. C control design. Half of the s only through questionnaire between air pollution and a Methodological limitations poor quantification of risk c |
| Yoshioka et al., (2010) | | investigated cytokine production and nuclear factor-kappaB (NF-kappaB) activation after stimulation of macrophage cells by exposure of urban aerosols. | evaluated the induction of airway inflammation in vitro and in vivo due to exposure of urban aerosols | urban aerosols induce resp inflammatory disease due t system. |
| Layshock et al., (2010) | China | this is the first report of dibenzopyrenes in the Beijing atmosphere and among the few studies that report these highly potent PAHs in ambient particulate matter . | Size fractionated particulate matter (PM) was collected in summer and winter from Beijing, China for the characterization of an expanded list of PAHs and evaluation of air pollution metrics. | Lifetime risk calculations in over 6 out of 100 Beijing res of lung cancer due to PAH lifetime risk was attributed |
| Longo et al., (2010) | on the island of Hawai'i | Kilauea Volcano population . Using a within-clinic retrospective cohort design, comparisons were made for visits of acute illnesses . | assess for a relative increase in cases of medically diagnosed acute illnesses in an exposed Hawaiian community. | There were statistically sign between high vog exposure diagnosed cough, headache airway problems. |

| Reference | Location | Population studied | Aims | Findings |
|-----------------------------|-------------------|---|--|---|
| Adar et al., (2010) | | participants (46 to 87 years of age) were without clinical cardiovascular disease at the baseline examination (2000-2002). Subcohort of MESA cohort study . | investigate cross-sectional associations between long- and short-term air pollution concentrations and microvascular characteristics using arteriolar vessel diameter as measured by retinal photography in MESA . | greater air pollution concentrations were associated with widened retinal arterioles. Among the 4,607 participants, those living in regions with increased long- and short-term |
| Balakrishnan et al., (2010) | Editorial , India | | For Integrated Urban-Rural Frameworks for Air Pollution and Health-Related Research in India | In an effort to close existing gaps in knowledge, the Medical Research (ICMR) has initiated Advanced Research in Environmental Health on air pollution and examining health outcomes in a rural-urban setting. An adult endovascular disease study, genetic modeling and select gene-environment interactions also being examined in a new study. The center will engage in capacity building and resource needs by developing a framework for categories of professionals. |
| Siddique et al. , (2010) | Delhi , India | cross-sectional study 969 school-going children (9-17 years) and 850 age- and sex-matched children from rural areas were assessed, | The prevalence of attention-deficit hyperactivity disorder (ADHD) was assessed in two childhood populations. | ADHD was found in 11.0% of the study population, contrast to 2.7% of the control group. Risk factors were male gender, 11-14 year age group, and PM ₁₀ exposure. ADHD was more prevalent in urban and rural areas. It was prevalent among children in Delhi against 4.0% of the general population. |

| Reference | Location | Population studied | Aims | Findings |
|----------------------------|-------------------|--|--|--|
| Tung et al . (2010) | Taiwan | Total of 3741 children was enrolled in the Taiwan Children Health Study from 14 communities. | investigate the associations of EPHX1 Tyr113His, His139Arg and GSTP1 Ile105Val polymorphisms with asthma and wheezing outcomes, and focused on the functional genetic change in different ambient NO(2) levels, GSTP1 and GSTM1 genotypes. | Children with high EPHX1 asthma and wheezing outcomes through airway oxidative stress. |
| Zhou et al., (2010) | China | Meta-analysis method was used to polysynthetically analyze 16 quantitative studies about the | associations between particulate air pollution and stroke daily attack or mortality. | There are positive associations between daily attack and mortality, associated with stroke attack. Increase in PM(10) was associated with stroke daily attack and 0.70 mortality . As for PM(2.5) 0.1 μ g/m(3) increase in stroke mortality. |
| Power et al., (2010) | USA | In a Cohort of Older Men 680 older men (mean ± age 71± 7 y) between 1996 and 2007. | To assess the association between black carbon, a marker of traffic-related air pollution, and cognition in older men. | The association between black carbon and cognition was linear and black carbon estimates were used in the analyses . Ambient traffic-related air pollution was associated with decreased cognition. |
| Novaes et al. , (2010) | São Paulo, Brazil | A panel study involving 55 volunteers was carried out in São Paulo, Brazil. | To explore the clinical relevance of chronic exposure to ambient levels of traffic derived air pollution on the ocular surface. | Subjects exposed to higher levels of traffic derived air pollution reported more ocular discomfort and presented greater tear film evaporation rate and ocular discomfort symptom score. The results used as convenient bioindicator of traffic derived air pollution. |

| Reference | Location | Population studied | Aims | Findings |
|-----------------------|-----------------|---|--|---|
| Phalen et al., (2010) | USA | ? | the doses delivered to subjects inhaling air-pollutant particles, the concept of a dose metric (also called an indicator) has emerged. An ideal dose metric has the following properties : it is measurable; it is expressible in physical and temporal scientific units; and it has a causal relationship to one or more biological responses | Recent advances include a aerosol dosimetry of the in on dose, including various obstructive pulmonary disease and bro physiological characteristic including transport of UF p olfactory nerves and through the lun lung resulting in localized I dosimetric modeling. |
| Puett et al., (2010) | | Using two prospective cohorts, the Nurses' Health Study (NHS) and the Health Professionals Follow-Up Study (HPFS), | investigated the relationship of incident type 2 DM with PM2.5, PM10, and PM10-2.5 exposures in the prior 12 months and distance to roadways. | results did not provide stro between exposure to PM in DM, however an associatio marker of exposure to traffi among women. |
| Zhuang et al., (2010) | Beijing , China | The monitoring data of daily air pollution, along with the daily numbers of outpatients visits at the Allergy Department of Beijing Shijitan Hospital from April to September in 2004 were collected. | assess the effects of ambient air pollutants on hospital outpatient visits for allergic disease and pollinosis. | significant positive associat airborne pollen and doctor 2.44% (95%CI: 0.75% - 4.13% (95%CI: 3.82% - 9.34%) for 1 mm(2) increase in pollen, in results suggest that level of stronger effect than ambien and pollinosis. |

| Reference | Location | Population studied | Aims | Findings |
|------------------------------|----------------------|---|---|---|
| Dadvand et al . , (2010) | northeast of England | used registry-based data on congenital heart disease for the population of the northeast of England in 1985-1996. | Investigate the association between maternal exposure to ambient air pollution and congenital heart disease | The authors found a weak association between exposure to black smoke and congenital cardiac chambers and conduction system as a continuous variable. With increasing exposure, odds ratios did not increase for consecutive quartiles. Findings were not indicative of any association. |
| Poursafa,&Kelishadi , (2010) | | | The effect of air pollution on inflammatory and pro-thrombotic factors implicated in the progression of cardiovascular diseases. | The systemic pro-inflammatory response to the inhalation of fine and ultrafine particles is seemingly associated with increased risk of cardiometabolic risk factors and may have a clinical significance for anti-platelet treatment. |
| Szyszkowicz et al. (2010) | Canada | Emergency visit data were collected in a hospital in Vancouver, Canada | Therefore the effects of ambient air pollution on emergency department (ED) visits for suicide attempts were investigated. | The results indicate a potential association between air pollution and emergency department visits for suicide attempts. Suicide attempts and depression may be linked to air pollution. |
| Brunekreef et al.,(2009) | Netherlands | a randomly selected subcohort of 5000 older adults participating in the ongoing Netherlands Cohort Study (NLCS) on diet and cancer. | the effects of traffic-related air pollution by analyzing associations with cause-specific mortality, as well as lung cancer incidence | traffic-related air pollution, particularly from diesel engines, is related to cardiopulmonary morbidity and mortality. |
| Carmichael et al., (2009) | Asia | Asia calculated over a 4-year period | Aerosol distributions in Asia calculated over a 4-year period and constrained by satellite observations of aerosol optical depth (AOD) are presented. | Black carbon (BC) concentrations in Asia represent 5-10% of the total aerosol loading, but contribute significantly to atmospheric absorption. BC is approximately 55% of the total aerosol loading in Asia. |

Table 1. Summary of harmful health effects of air pollutants

| Reference | Location | Population studied | Aims | Findings |
|---------------------------|----------|--|---|--|
| Nurkiewicz et al., (2008) | | closer examination by toxicologists of vascular responses following PM exposure | impairment of endothelium-dependent dilation | Increased systemic inflammation and oxidative stress |
| Simpson R et al., (2005) | Austria | Brisbane, Melbourne, Perth and Sydney population | investigating the health effects of air pollution on daily mortality | Strongest associations for nitrogen dioxide and ozone. For each 10 µg/m ³ increase in PM2.5 concentration, there was an increase of approximately a 1% in deaths. |
| Pope et al., (2002) | USA | The risk factor data for approximately 500 000 adults were linked with air pollution data for metropolitan areas | To assess the relationship between long-term exposure to fine particulate air pollution and all-cause, lung cancer, and cardiopulmonary mortality | each 10 mg/m ³ elevation in fine particulate pollution was associated with a 16% increase in all-cause and 8% increased risk of lung cancer mortality, |
| Lewis PR et al., (1998) | | La Trobe Valley | | Respiratory morbidity with outdoor air pollution |

The relationship of long-term traffic exposure (NO₂ level by residence) and diabetes mellitus is documented (Brook et al., 2008). The first biological support for this finding comes from our study that demonstrated an independent association of exposure to air pollutants, notably PM₁₀, with markers of insulin resistance among children and adolescents (Kelishadi et al.,2009), as cited in the statement of the American Heart Association (Brook et al.,2010).

These findings suggest that the systemic responses to long-term exposure to air pollutants could potentially increase the risk for development of the metabolic syndrome, hypertension and diabetes mellitus.

Some study findings on the association of air pollution with surrogate markers of atherosclerotic cardiovascular diseases in children and adolescents is presented in Table2.

| Reference | Location | Population studied | Aims | Findings |
|---|--------------|--|--|--|
| Inflammation, Coagulation, Oxidative stress | | | | |
| Poursafa & Kelishadi (2010) | Review | Review on the effects of air pollution on platelets | The increase of platelet count and platelet hyper-reactivity towards agonists are emerging as markers of hematologic and hemostatic changes in response to the exposure to air pollutants. The systemic pro-inflammatory and pro-thrombotic response to the inhalation of fine and ultrafine particulate matters is seemingly associated with platelet activation. | It is of particular relevance to further study the significance of platelet activation and anti-platelet therapies in primordial/primary preventive measures in children and adolescents at risk of accelerated atherosclerosis. |
| Kelishadi et al.(2009) | Isfahan,Iran | A population-based sample of children aged 10-18 years (n=374) | To determine the association of air pollution as well as dietary and physical activity habits with markers of inflammation, oxidative stress and insulin resistance | The Pollutant Standard Index (PSI) and the level of fine particulate matter had significant independent association with all biomarkers studied. |

| Reference | Location | Population studied | Aims | Findings |
|-------------------------|----------------|--|---|--|
| Yang et al.(2008) | Review | Review of studies on air pollution and chronic obstructive pulmonary diseases, cardiovascular diseases, asthma, and cancer | To provide some insight about the health problems associated with various air pollutants and their relationship in promoting chronic diseases through changes in oxidative stress and modulation of gene expression | Byproducts of oxidative stress found in air pollutants are common initiators or promoters of the damage produced in chronic diseases. |
| Chuang et al., (2007) | Taipei, Taiwan | Young healthy university students (n=76) | To investigate whether biological mechanisms linking air pollution to cardiovascular events occurred concurrently in human subjects exposed to urban air pollutants | Air pollution is associated with inflammation, oxidative stress and blood coagulation in healthy young humans. |
| Endothelial dysfunction | | | | |
| Poursafa et al.(2011) | Iran | Healthy children | To assess the relationship of air pollution and plasma surrogate markers of endothelial dysfunction in the pediatric age group | The independent relationship of air pollutants with endothelial dysfunction and a pro-coagulant state can be an important factor in atherosclerosis development from early life. |

| Reference | Location | Population studied | Aims | Findings |
|------------------------|----------|--|---|---|
| Brook (2008) | Review | Review of studies on air pollution and cardiovascular diseases | To address the cardiovascular effects of air pollution and related mechanisms | Air particle exposure may both trigger acute events as well as prompt the chronic development of cardiovascular diseases, one of the mechanisms is by triggering acute endothelial dysfunction. |
| Nadadur et al., (2007) | USA | Differential gene expression and transcription factor activation profiles in human vascular endothelial cells exposed to a non-cytotoxic dose of fly ash or V following semi-global gene expression profiling of approximately 8000 genes. | To explore potential biomarkers for PM-induced endothelial dysfunction | Cardiovascular effects associated with exposure to PM may be mediated by perturbations in endothelial cell permeability, Membrane integrity; and ultimately endothelial dysfunction. |

Table 2. Summary of studies assessing the effects of criteria air pollutants on inflammation, coagulation, oxidative stress and endothelial dysfunction among children and young adults

6. Environmental factors, lifestyle behaviors and chronic diseases

Usually improper lifestyle habits and low educational levels have been considered as the underlying process of the role of low socio-economic position in early life as a predisposing factor for future chronic diseases (Power, et al., 2007) and mortality (Strand & Kunst, 2007), the exposure to air pollutants and its effects on low birth weight and premature birth might have an additional role in this regard.

Lifestyle modifications and strengthening primary care in health system are suggested as the main strategies to prevent and control chronic diseases in low- and middle-income countries (Miranda et al., 2008).

The association between air pollution and chronic diseases may be mediated through systemic inflammatory responses (Brook et al., 2004; Holgate et al. 2003). Generating

reactive oxygen species is considered to be linked to a variety of environmental factors. The association of air pollution and inflammation/oxidative stress has been demonstrated (Huang et al., 2003; Ruckerl et al. 2006; Chuang et al., 2007), even among healthy children (Kelishadi et al., 2009) who might have the early stages of atherosclerosis. Such association is also confirmed for air pollutants, notably particulate matters and surrogate markers of endothelial dysfunction and markers of vascular injury (Poursafa et al., 2011). The effects of air pollution on inflammation, coagulation, oxidative stress and endothelial dysfunction from early life confirm the necessity of implications of these findings in relation to public health and regulatory policies for primordial/primary prevention and control of adult chronic diseases from childhood.

The prevalence of malignancies are rapidly accelerating worldwide. Although lifestyle behaviors as smoking (Dominguez et al., 2006), as well as unhealthy dietary and physical activity habits leading to obesity and diabetes are known as a major contributing factor in this regard (Hjartåker et al., 2008), air pollution should be considered as another potential risk factor for developing countries (Nejjari et al., 2003) especially Asian countries, where cancer has become an emerging health threat (Park et al., 2008). This issue is particularly important for children who are susceptible to short-term and long-term effects of air pollutants.

7. Conclusion

Air pollution is a global health issue with serious public health implications particularly for children. Usually respiratory effects of air pollutants are being considered, the importance of other health hazards should be highlighted. In addition to short-term effects, exposure to criteria air pollutants from early life might have long-term hazards principally on chronic non-communicable diseases as cardiovascular diseases and cancers. In view of the emerging epidemic of chronic disease in low- and middle- income countries, the vicious cycle of rapid urbanization in such communities resulting in increasing levels of air pollution and its consequent effects on chronic diseases, as well as the limited financial resources of these countries for planning effective air pollution control programs, public health and regulatory policies for air quality protection should be integrated into the main priorities of primary health care system and into the educational curriculum of health professionals.

We suggest that environmental protection activities, particularly for reducing the emission of criteria air pollutants, should be considered for public health measures taken into account for primordial/primary prevention of chronic diseases especially in developing countries.

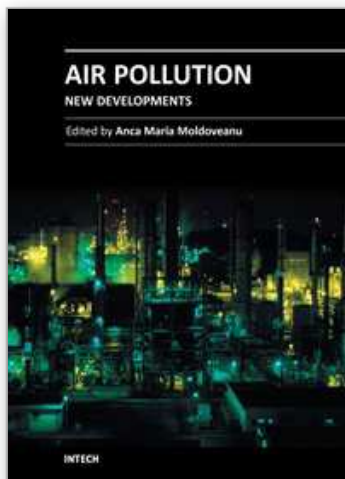
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Today, an important issue is environmental pollution, especially air pollution. Due to pollutants present in air, human health as well as animal health and vegetation may suffer. The book can be divided in two parts. The first half presents how the environmental modifications induced by air pollution can have an impact on human health by inducing modifications in different organs and systems and leading to human pathology. This part also presents how environmental modifications induced by air pollution can influence human health during pregnancy. The second half of the book presents the influence of environmental pollution on animal health and vegetation and how this impact can be assessed (the use of the micronucleus tests on *TRADESCANTIA* to evaluate the genotoxic effects of air pollution, the use of transplanted lichen *PSEUDEVERNIA FURFURACEA* for biomonitoring the presence of heavy metals, the monitoring of epiphytic lichen biodiversity to detect environmental quality and air pollution, etc). The book is recommended to professionals interested in health and environmental issues.

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