Health Impacts Of Air Pollution

A Compilation of Health & Air Pollution Studies

www.dfca.org.in
Air pollution was responsible for 7 million premature deaths in 2016, of these almost 600,000 were children under 5 years old.
In Polluted Cities
Breathing Kills!
Introduction

“The health effects of air pollution imperil human lives. This fact is well documented” - Eddie Bernice Johnson

In 2016, ambient air pollution caused 4.2 million deaths*

- 16% of the lung cancer deaths.
- 25% of chronic obstructive pulmonary disease (COPD) deaths.
- 17% of ischaemic heart disease and stroke deaths.
- 26% of respiratory infection deaths.

Of the total 480.7 million DALYs in India in 2017, 38.7 million or 8.1% were attributable to air pollution.

Of the total DALYs attributable to air pollution in India in 2017, the largest proportions were from lower respiratory infections (29.3%), chronic obstructive pulmonary disease (29.2%), and ischaemic heart disease (23.8%), followed by stroke (7.5%), diabetes (6.9%), lung cancer (1.8%), and cataract (1.5%).


Available from: https://www.thelancet.com/action/showPdf?pii=S2542-5196%2818%2930261-4
Air Pollution And Respiratory Effects

- Airway obstruction
- Cough
- Wheezing
- Shortness of breath
- Asthma
- Emphysema
- Chronic Obstructive Pulmonary disease (COPD)
- Lung Cancer
- Pneumonia
- Tuberculosis

According to State of global Air Report 2019-
Air pollution accounts for 41% of global
deaths from chronic obstructive pulmonary
disease (COPD), 19% of deaths from lung
cancer, 35% of deaths from lower-respiratory
infection.

**Study:** Air pollution, weather, and associated risk factors related to asthma prevalence and attack rate by Ho WC et al (2007).

**Objective:** To investigate the relationship of air pollution and weather to adolescent asthma prevalence and attack rate.

A 6-month study (October 1995 to March 1996) in Taiwan with the study population of 1,139,452 students. A stratified random sample of 64,660 students was analyzed for asthma prevalence and attack rate. The study demonstrated that air pollution is related to asthma attack rate.
**Study:** Outdoor air pollution and emergency room visits at a hospital in Delhi by Pande JN et al (2002).

Study was undertaken to correlate the daily levels of various pollutants with the number of patients visiting the All India Institute of Medical Sciences, New Delhi casualty for aggravation of certain defined cardiorespiratory disorders from January 1997 to December 1998.

**Findings:** Emergency room visits for asthma, chronic obstructive airway disease (COAD) and acute coronary events increased by 21.30%, 24.90% and 24.30% respectively on account of higher than acceptable levels of pollutants.
Study: Pulmonary Health Effects of Air Pollution by Kurt OK et al (2016)

Two studies of Chinese school children in 2013 and 2014, found long-term exposure to ambient air pollution was associated with a number of adverse effects, such as wheezing, cough or phlegm.

A systematic review published in 2015 suggests that exposure in early childhood to traffic-related air pollution (TRAP) containing PM2.5 was associated with an increased incidence of asthma up to the age of 12 years.

Study from Japan in 2014 of 10,069 children aged 6-9 years found traffic-related air pollution (TRAP) associated with development of asthma.

**Study:** Outdoor air pollution and lung cancer: Recent epidemiologic evidence by Vineis P et al (2004)

The Harvard Six Cities Study was based on 8,111 residents of 6 U.S. cities, followed from 1974 through 1989. Exposure was estimated on the basis of average levels of pollution over the risk period, assuming residential stability. The total number of lung cancer deaths was reported as 8.4% of 1,429 (or 120).

Nafstad et al. studied lung cancer incidence among 16,209 (40 to 49 year) old men living in Oslo. Exposure assessment was based on measured concentrations of 2 gaseous air pollutants (NO2 and SO2) available from 1974 to 1995. The authors found a risk ratio of 1.08 for an increment of 10µg/m3 of NO2.


The authors assessed the relationship between daily changes in respiratory health and particulate levels with diameters of (a) less than 10 micron (PM10) and (b) less than 2.5 micron (PM2.5) in Kanpur, India. The subjects (N = 91) were recruited from 3 areas in Kanpur: Indian Institute of Technology, Vikas Nagar, a typical commercial area and the residential area of Juhilal Colony. All subjects resided near to air quality monitoring sites. Air quality and peak expiratory flow rate samplings were conducted for 39 d. Once during the sampling period, lung-function tests (i.e., forced expiratory volume in 1 s, forced vital capacity) were performed on each subject. The authors used a statistical model to estimate that an increase of 100 microg/m3 of the pollutant PM10 could reduce the mean peak expiratory flow rate of an individual by approximately 3.2 l/min.

Air Pollution & Cardiovascular Effects
Air Pollution And Cardiovascular Effects

- Increase risk of Myocardial infarction
- Coronary artery disease
- Ischemic heart disease
- Heart failure
- Arrhythmias
- Stroke
- Increase risk of cardiovascular mortality
- Hypertension
- Arteriosclerosis

16% of deaths from ischemic heart disease, and 11% of deaths from stroke (State of global Air Report 2019)


The effect of changes in daily levels of particulate matter (PM10) and ozone (O3) on hospitalization for all, cardiovascular and respiratory causes in the two hospitals in Nicosia during 1 January 1995 and 30 December 2004 was investigated.

Results: For every 10 μg/m3 increase in daily average PM10 concentrations, there was a 0.9% increase in all-cause and 1.2% increase in cardiovascular admissions. With respect to respiratory causes, an effect was observed only in the warm months. All-cause and cardiovascular admissions were 4.8% and 10.4% higher on dust storm days respectively.
**Study: Global association of air pollution and heart failure: a systematic review and meta-analysis by Shah AS et al (2013)**

To assess the association between air pollution and acute decompensated heart failure including hospitalization and heart failure mortality. There was a positive association between short-term increase in PM (PM$_{2.5}$ 2.12% per 10 μg/m$^3$) and gaseous components (NO$_2$-1.70% per 10 parts per billion, SO$_2$- 2.36% per 10 parts per billion, CO - 3.52% per 1 part per million) and an increased risk of hospitalization or death from congestive heart failure, with the strongest associations on the day of exposure, and more persistent effects for PM2.5.

**Study:** Long-term air pollution exposure and cardio-respiratory mortality: a review. Environ Health by Hoek G et al (2013)

A 2013 meta-analysis found that an average increase of 11% in cardiovascular mortality was associated with a 10 μg/m3 increase in annual PM 2.5 concentration.


1,001,166 people were enrolled from 1997 to 2007 and followed for an average of 11.5 years.

Findings: Annual increases of 10 μg/m3 in PM10 and 5 μg/m3 in PM2.5 were associated with increased risks of coronary events (myocardial infarction and unstable angina) of 12% and 13%, respectively.

Conclusion: Long term exposure to particulate matter is associated with incidence of coronary events.

Air Pollution & Brain
Air Pollution And Brain

- Autism/autistic spectrum disorders
- Oxidative stress
- Neuroinflammation
- Neurodegenerative diseases
- Depression
- Decrease cognitive function
- Developmental disabilities
- Behavioral abnormalities and many more


https://www.momscleanairforce.org/fine-particle-brain-damage/

According to data from China (Chen S et al) published in 2018, every 1 standard deviation rise in particulate matter over an average PM2.5 concentration increases the likelihood of having mental illness (including depression) by 6.67%, translating to an annual medical expense of $22.88 billion USD.

Mohan Kumar et al found that air pollutants, specifically particulate matter, induce inflammation and oxidative stress in the brain that can lead to the manifestation of depression.

Vert et al found that the rate of depression was 2 times higher for each 10 μg/m3 increase in the nitric oxide level.
**Study:** Neurotoxicants are in the Air: Convergence of Human, Animal and *In Vitro* Studies on the Effects of Air Pollution on the Brain by Costa LG et al (2014)

Two studies by Volk et al. found that residential proximity to freeways and gestational and early life exposure to traffic-related air pollution were associated with autism (OR = 1.86; 95% CI 1.04–3.45).

Newman et al. reported hyperactivity in 7-year-old children associated with early life exposure to traffic related air pollution.


Diesel exhaust exposure was significantly associated with autism spectrum disorders (ASD), particularly in boys. There is increasing evidence indicating that children with ASD have higher levels of oxidative stress as well as increased neuro inflammation and systemic inflammation, these are the typical effects found in individuals exposed to severe air pollution.
Study: Air pollution and daily emergency department visits for depression by Szyszkowicz M et al (2009)

Objective: To investigate the potential correlation between ambient air pollution exposure and emergency department (ED) visits for depression. A hierarchical clusters design was used to study 27,047 ED visits for depression in six cities in Canada.

Findings: The percentage increase in daily ED visits was 15.5% for CO per 0.8 ppm and 20.0% for NO2 per 20.1 ppb. 7.2% increase in the risk of emergency department visits for depressive episodes with every 19.4 μg/m3 of PM10 concentration (October-March). The results support the hypothesis that ED visits for depressive disorder correlate with ambient air pollution.

Study: Air Pollution and Emergency Department Visits for Depression: A Multicity Case-Crossover Study by Szyszkowicz M et al (2016)

Aim: To investigate the associations between ambient air pollution and emergency department (ED) visits for depression. ED visits for depression were retrieved from the National Ambulatory Care Reporting System. A case-crossover design was employed for this study.

Findings: For females, exposure to ozone was associated with increased risk of an ED visit for depression between 1 and 7 days after exposure, for males, between 1 and 5, and 8 days after exposure, with odds ratios ranging between 1.02 and 1.03. These findings suggest that there is a positive association between exposure to air pollution and ED visits for depression.

Study: Association between ambient and household air pollution with carotid intima-media thickness in peri-urban South India: CHAI-Project by Ranzani OT et al (2019)

To evaluate the association between ambient fine particulate matter [particulate matter with an aerodynamic diameter of 2.5 mm (PM2.5)] and biomass fuel use on carotid intima-media thickness CIMT), a surrogate of atherosclerosis, in India. Analyzing of the third follow-up of the Andhra Pradesh Children and Parent Study cohort (2010–2012), which recruited participants from 28 peri-urban villages.

Findings: Among 3278 participants mean PM2.5 was 32.7 µg/m3 , and 60% used biomass. Positive associations was found between within-village variation in PM2.5 and CIMT in all participants [1.79%, 95% CI], 0.31 to 3.90 per 1 µg/m3 of PM2.5] and in men (2.98%, 95% CI, 0.23–5.72, per 1 µg/m3 of PM2.5). Use of biomass cooking fuel was associated with CIMT in all participants. Ambient and household air pollution were positively associated with CIMT in a peri-urban population of India.
Air Pollution & Reproductive & Neonatal Effects
Air Pollution And Reproductive And Neonatal Health

- Low fertility rate
- Sperm aneuploidy
- Abortion
- Low birth weight
- Intrauterine growth reduction
- Neonatal mortality
- Post neonatal mortality


Aim: To assess the association between traffic related air pollution and fertility rates in humans in Barcelona, Spain (2011–2012). General fertility rate was calculated - number of live births per 1000 women between the ages of 15 and 44 years per census tract.

Findings: Statistically significant reduction of fertility rates with an increase in traffic related air pollution levels, particularly for the coarse fraction of particulate matter was found. According to authors this was the first study in humans which showed an association between reduced fertility rates and higher traffic related air pollution levels.

The study population consisted of 212 men who were attending an infertility clinic for diagnostic purposes. Sperm aneuploidy for chromosomes 13, 18, 21, X, and Y was assessed using multicolor fluorescence in situ hybridization. Air quality data were obtained from the Air Base database.

Findings: Positive associations were observed between exposure to PM2.5 and disomy Y (P = 0.001), sex chromosome disomy (P = 0.05) and disomy 21 (P = 0.03). Exposure to PM10 was associated with disomy 21 (P = 0.02). A separate analysis conducted among men who were nonsmokers (n = 117) showed that the relationship between PM2.5 and disomy Y and disomy 21 remained significant. These findings indicate that exposure to air pollution induces sperm aneuploidy.
**Study:** Fetal growth and maternal exposure to particulate matter during pregnancy by Dejmek J et al (1999)

Authors examined the possible impact of particulate matter up to 10 micron (PM10) and up to 2.5 micron (PM2.5) in size on intrauterine growth retardation (IUGR) risk in a highly polluted area of Northern Bohemia (Teplice District). The study group includes all singleton full-term births of European origin over a 2-year period in the Teplice District.

**Findings:** Increase in IUGR were associated with PM 10 levels over 40 μg/m3 and PM 2.5 levels over 37 μg/m3 during early pregnancy in the highly polluted district of Teplice. This relationship remained after controlling for season.
**Study:** The impact of polycyclic aromatic hydrocarbons and fine particles on pregnancy outcome by Dejmek J et al (2000).

The impact of c-PAHs and fine particles on IUGR was analyzed in Teplice and in Prachatice, a region with similarly high c-PAH but low particle levels. All European, single live births occurring in a 4-year period in Teplice (n = 3,378) and Prachatice (n = 1,505) were included. Mean PM(10), PM(2.5,) and c-PAHs levels during the 9 gestational months (GM) were estimated for each mother. For each 10 ng increase of c-PAHs in the first Gestational month, the Adjusted odds ratio was 1.22 (CI, 1.07-1.39). The results proved that exposure to c-PAHs in early gestation may influence fetal growth.


https://metro.co.uk/2019/09/18/study-finds-carbon-particles-air-pollution-placentas-pregnant-women-10763154/
Study: Exposures to fine particulate matter (PM2.5) and birthweight in a rural-urban, mother-child cohort in Tamil Nadu, India by Balakrishnan K et al (2018)

Objective: To examine whether PM2.5 exposures during pregnancy were associated with birth weight in an integrated rural-urban, mother-child cohort in the state of Tamil Nadu, India.

1285 pregnant women were recruited in the first trimester of pregnancy from primary health care centers and urban health posts and followed them until birth to collect antenatal care data and birth weight. Estimation of pregnancy period PM2.5 exposures through direct serial measurements of 24-h household PM2.5 concentrations, performed across each trimester.

Findings: A 10-μg/m3 increase in pregnancy period PM2.5 exposures was associated with a 4g decrease in birth weight and 2% increase in prevalence of low birth weight. The study provides some of the first quantitative effects estimates for linking rural-urban PM2.5 exposures and birth weight in India.

**Study:** Impact of air pollution on reproductive health by Sram R (1999) Woodruff et al. (1997) found that post neonatal mortality was associated with the PM10 level in the United States.

Bobak and Leon (1999) observed an association of total suspended particles and SO2 with Low birth weight in an ecologic study conducted in the Czech Republic in 1986-1988. **Barker (1995)** showed a relationship between some serious adult risks (namely, noninsulin-dependent diabetes, hypertension, and coronary heart disease) and impaired growth in the prenatal and early postnatal period. In this study, Barker (1995) implied that higher exposure to pollutants during the early stages of intrauterine life may be responsible for diseases in middle age.
Direct And Indirect Impact Of Air Pollution In Pregnancy On Adverse Birth Outcomes And Lung Development

Air Pollution & Diabetes
**Study:** Ambient air pollution in relation to diabetes and glucose-homoeostasis markers in China: a cross-sectional study with findings from the 33 Communities Chinese Health Study by Yang BY et al (2018)

Between April 1 and Dec 31, 2009, a total of 15,477 participants aged 18–74 years were recruited from a large cross-sectional study (the 33 Communities Chinese Health Study) from three cities in Liaoning province, northeastern China.

**Findings:** All the studied pollutants were significantly associated with increased diabetes prevalence (eg, the adjusted odds ratios associated with an increase in IQR for PM1, PM2.5, and PM10 were 1.13, 95% CI 1.04–1.22; 1.14, 1.03–1.25; and 1.20, 1.12–1.28, respectively). These air pollutants were also associated with higher concentrations of fasting glucose, 2 h glucose and 2 h insulin. Long-term exposure to air pollution was associated with increased risk of diabetes in a Chinese population, particularly in individuals who were younger or overweight or obese.
**Study:** Ambient air pollution and diabetes: A systematic review and meta-analysis by Yang B-Y et al (Available online 2019)

Review of epidemiological studies to quantify the association between air pollutants and type 2 diabetes (T2D), and to answer if diabetes patients are more vulnerable to air pollutants.

Out of 716 articles identified, 86 were used for this review and meta-analysis. Meta-analyses showed significant associations of PM2.5 with T2D incidence (11 studies; HR=1.10, 95% CI=1.04–1.17 per 10 μg/m3 increment) and prevalence (11 studies; OR=1.08; 95% CI=1.04–1.12 per 10 μg/m3 increment) of PM10 with T2D prevalence (6 studies; OR=1.10; 95% CI=1.03–1.17 per 10 μg/m3 increment) and incidence (6 studies; HR=1.11; 95% CI=1.00–1.22 per μg/m3 increment), and of NO2 with T2D prevalence (11 studies; OR=1.07; 95% CI=1.04–1.11 per 10 μg/m3 increment).

**Conclusion:** Recent publications strengthened the evidence for adverse effects of ambient air pollutants exposure (especially for PM) on T2D and that diabetic patients might be more vulnerable to air pollutants exposure.

Study: Air Pollution as a Risk Factor for Type 2 Diabetes by Rao X et al (2015)

Kramer et al (2010) conducted an investigation of the association of incident T2DM with ambient air pollution using data from the Study on the Influence of Air Pollution on Lung, Inflammation and Aging (SALIA) cohort in Germany. Non diabetic women who were 54–55 years old at baseline (1985–1995) were followed until 2006. The authors found that T2DM incidence increased by 15% per interquartile range of traffic-related PM or by 15% to 42% per interquartile range of NO2.
Air Pollution as a Risk Factor for Type 2 Diabetes by Rao X et al (2015)

Andersen et al. followed 51,818 participants of the Danish Diet, Cancer, and Health cohort in the Danish National Diabetes Register from baseline (1993–1997) to 2006. Nitrogen dioxide levels were measured at the residential addresses of the cohort participants. After an average of 9.7 years of follow-up, they detected a positive association between air pollution and confirmed cases of diabetes [hazard ratio (HR) 1.04 (95% CI 1.03–1.08)] per interquartile range of 4.9 mg/m² mean NO₂ levels.
Air Pollution as a Risk Factor for Type 2 Diabetes by Rao X et al (2015)

In one of the few incident studies of T2DM and ambient air pollution exposure among African-Americans, Coogan et al (2012) followed 3992 women residing in Los Angeles from 1995 to 2005. The authors reported that those who had higher exposure to air pollutants (PM2.5 and NO2) were more likely to develop T2DM. The incidence rate ratio (IRR) for T2DM for a 10 mg/m3 increase in PM2.5 was 1.63 (95% CI 0.78–3.44), and the IRR for NO2 (per 12.4 parts per billion) was 1.14 (95% CI 1.07–1.46).
Air Pollution & Liver
# Air Pollution And Liver

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Air pollutants</th>
<th>Mechanism of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatotoxicity</td>
<td>Coal fly ash</td>
<td>Lipid peroxidation, Hepatic megalocytosis, DNA damage</td>
</tr>
<tr>
<td></td>
<td>PM$_{2.5}$ or CB</td>
<td>Generation of ROS, Lipid peroxidation, Genotoxicity, ER stress</td>
</tr>
<tr>
<td></td>
<td>DEP</td>
<td>Genotoxicity, Generation of ROS</td>
</tr>
<tr>
<td>NAFLD and Type II diabetes</td>
<td>PM$_{2.5}$ or CB</td>
<td>Kupffer cell activation and Production of pro-inflammatory cytokine, Impaired hepatic glycogen storage, glucose intolerance and insulin resistance, Alteration of lipid homeostasis and Visceral adipose tissue inflammation, Imbalance in circulating leptin/adiponectin levels</td>
</tr>
<tr>
<td></td>
<td>DEP</td>
<td>Oxidative stress, DNA damage</td>
</tr>
<tr>
<td>Liver fibrosis</td>
<td>The total extracts or the PAH fraction of airborneparticles</td>
<td>Mitochondrial and Hematogenic damage</td>
</tr>
<tr>
<td>Liver cancer</td>
<td>2-NBA, 3-NBA</td>
<td>Genotoxicity, Mutagenic and Carcinogenic activity</td>
</tr>
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</table>

Study: Particulate matter air pollution and liver cancer survival Deng H et al (2017)
Twenty thousand, two hundred and twenty-one California Cancer Registry patients with hepatocellular carcinoma (HCC) diagnosed between 2000 and 2009 were used to examine the effect of exposure to ambient PM with diameter <2.5 μm (PM$_{2.5}$) on HCC survival.

Findings: PM$_{2.5}$ exposure after diagnosis was statistically significantly associated with HCC survival. After adjustment for potential confounders, the all-cause mortality hazard ratios (HR) associated with a 1 standard deviation (5.0 μg/m$^3$) increase in PM$_{2.5}$ was 1.18 (95% CI: 1.16-1.20); 1.31 (95% CI:1.26-1.35) for local stage, 1.19 (95% CI:1.14-1.23) for regional stage, and 1.05 (95% CI:1.01-1.10) for distant stage.
Exposure to elevated PM$_{2.5}$ after the diagnosis of hepatocellular carcinoma may shorten survival, with larger effects at higher concentrations.
Air Pollution & Obesity
**Study:** Traffic-related air pollution and obesity formation in children: a longitudinal, multilevel analysis by Jerrett M et al (2014)

Participants were drawn from a prospective cohort of children who lived in 13 communities across Southern California (N = 4550). Children (5-11 years) were enrolled while attending kindergarten and first grade and followed for 4 years, with height and weight measured annually.

**Findings:** Traffic pollution was positively associated with growth in BMI. The effect size in the adjusted model indicated about a 13.6% increase in annual BMI growth when comparing the lowest to the highest tenth percentile of air pollution exposure, which resulted in an increase of nearly 0.4 BMI units on attained BMI at age 10.

**Study:** Impact of ambient air pollution on obesity: a systematic review by An R et al (2018)

A literature search was conducted in the PubMed and Web of Science for peer-reviewed articles published until September 2017 that assessed the relationship between air pollution and body weight status.

**Result:** Sixteen studies met the selection criteria and were included in the review. They were conducted in seven countries, including the US, China, Canada, Italy, Netherland Serbia and South Korea. Commonly examined air pollutants included PM, NO₂, SO₂, O₃, and overall air quality index. Among a total of 66 reported associations between air pollution and body weight status, 29 (44%) found air pollution to be positively associated with body weight, 29 (44%) reported a null finding, and the remaining eight (12%) found air pollution to be negatively associated with body weight.

**Conclusion:** Concurrent evidence regarding the impact of air pollution on body weight status remains mixed.
Study: Ambient air pollution and overweight and obesity in school-aged children in Barcelona, Spain by de Bont J et al (2019)
Authors studied 2660 children aged 7-10 years during 2012 in Barcelona.

Results: An interquartile range increase in PM$_{10}$ home (5.6 μg/m$^3$) was associated with a 10% increase in the odds of being overweight or obese. Children exposed to the highest tertile of Ultra fine particle (UFP)-school (>27,346 particles/cm$^3$) had a 30% higher odds of being overweight or obese compared to the lowest tertile of UFP exposure. Authors observed that exposure to NO$_2$, PM$_{2.5}$ or Elemental carbon at schools was associated with higher odds of overweight or obese at medium compared to low levels of exposure.

Conclusion: Exposure to ambient air pollution, especially at school, was associated with childhood risk for overweight and obesity. A cautious interpretation is warranted because associations were not always linear and because school and home air pollution measurements were not directly comparable.
Air Pollution & Skin
Air Pollution And Skin

- Atopic Dermatitis
- Skin Aging
- Contact Dermatitis
- Psoriasis
- Urticaria
- Eczema,
- Pigmentation
- Acneiform Eruptions
- Acne
- Skin Cancer


Air Pollution And Skin

- Exposure to ozone has been associated with urticaria, eczema, contact dermatitis and other nonspecific eruptions.

- Polyaromatic hydrocarbons cause skin cancer, extrinsic skin aging, pigmentation and acneiform eruptions.

- Oxides have been associated with increased prevalence, as well as exacerbations of atopic dermatitis in children.
Air Pollution And Skin

Study: Symptoms of atopic dermatitis are influenced by outdoor air pollution by Kim J (2013)

Long-term study to evaluate the clinical effects of outdoor air pollution on skin symptoms in patients with Atopic dermatitis (AD).

Twenty two patients (17 boys and 5 girls) enrolled with AD living in Seoul, Korea, and followed them for 18 months between July, 2009, and December, 2010.

The authors obtained daily mean concentrations of particulate matters (PMs), nitric oxides (NO, NO2, NOx), volatile organic compounds (VOCs) including benzene, toluene, ethyl-benzene, xylene, and styrene, and 24 hour average temperature and relative humidity from the closest monitoring sites to each patient’s residence during the study period to estimate the patients’ exposure to outdoor air pollution and meteorological conditions.
The authors found that AD symptoms were associated with the levels of outdoor air pollutants such as PM, toluene, and total volatile organic compounds (TVOC). This association varied according to season, and the lag effect of PM10, benzene, and TVOC on AD symptoms was found after exposure. The authors’ findings suggest that outdoor air pollution acts as an aggravating factor in AD.
Air Pollution & Obesity

Nationwide survey of middle-school students in Taiwan from 1995 to 1996 was conducted. The 12-month prevalence of eczema was compared with air monitoring station data of temperature, relative humidity, and criteria air pollutants.

A total of 317,926 children attended schools located within 2 km of 55 stations.

Findings: Prevalence rates of recurrent eczema were 2.4 and 2.3% in boys and girls, respectively, with prevalence rates of flexural eczema 1.7% in both sexes. After adjustment for possible confounders, flexural eczema was found to be associated with traffic-related air pollutants, including nitrogen oxides and carbon monoxide. Recurrent eczema was associated with traffic-related air pollution only in girls.
Study: Acute health effects of urban fine and ultrafine particles on children with atopic dermatitis by Song S et al (2011)

Forty one schoolchildren, 8-12 years old, who had been diagnosed with atopic dermatitis were included.

For 67 consecutive days, all of them measured their symptoms in a diary. To assess exposure, the daily ambient mass concentrations of particulate matter less than 10, 2.5 and 1 μm and concentrations of submicron particles (0.01- 1 μm) were measured at a local school.

Findings: Significant associations were found between the concentrations of ultrafine particles and the itchiness symptom in children with atopic dermatitis. The results suggested that the concentration of ambient ultrafine particles may exacerbate skin symptoms in children with atopic dermatitis.
Skin responses to air pollutions (particulate matter, PM; polycyclic aromatic hydrocarbons PAH; and ozone, $O_3$) and ultraviolet radiation.
Air Pollution & Gastrointestinal Effects
Air Pollution And Gastrointestinal Effect

- Appendicitis
- Inflammatory bowel disease/ Crohn disease
- Increases Intestinal Permeability

**Study:** Ambient air pollution correlates with hospitalizations for inflammatory bowel disease: an ecologic analysis by Anantha krishnan AN et al (2011)

Data from the Wisconsin Hospital Association (WHA) for the year 2002 was used to identify the number of IBD-related hospitalizations for each of the 72 counties in Wisconsin.

**Results:** There was a mean of 81.3 Inflammatory bowel disease (IBD) hospitalizations/100,000 population per county. The total criteria pollutant emissions density correlated significantly with adult IBD hospitalizations. On Poisson regression, a 1-log increase in the density of total criteria pollutant emission was associated with a 40% increase in the rate of IBD hospitalizations. Total air emissions of criteria pollutants appear to be associated with hospitalizations for IBD in adults.


The health improvement network (THIN) database in the United Kingdom was used to identify incident cases of Crohn's disease (n=367) or ulcerative colitis (n=591), and age and sex-matched controls.

Findings: Overall, NO(2), SO(2), and PM(10) were not associated with the risk of IBD. However, individuals ≤23 years were more likely to be diagnosed with Crohn's disease if they lived in regions with NO(2) concentrations within the upper three quintiles (odds ratio (OR)=2.31; 95% confidence interval (CI)=1.25-4.28), after adjusting for confounders. Air pollution exposure was not associated with the incidence of IBD. However, residential exposures to SO(2) and NO(2) may increase the risk of early-onset ulcerative colitis and Crohn's disease, respectively.
Study: Effect of ambient air pollution on the incidence of appendicitis by Kaplan GG et al (2009)

Identification of 5191 adults who had been admitted to hospital with appendicitis between Apr. 1, 1999, and Dec. 31, 2006. The air pollutants studied were ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide, and suspended particulate matter of less than 10 μ and less than 2.5 μ in diameter. An increase in the interquartile range of the 5-day average of ozone was associated with appendicitis. In summer (July–August), the effects were most pronounced for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter less than 10 μ in diameter. The findings suggest that some cases of appendicitis may be triggered by short-term exposure to air pollution.
# Air Pollution and Kidney

## Particulate Matter (Fine Particle) and Urologic Diseases

Eun-A Kim
Occupational Safety and Health Research Institute, Korea Occupational Safety and Health Agency, Ulsan, Korea

### Table 1. Summary of studies on the effects of particulate matter on the kidneys

<table>
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<th>Study</th>
<th>Method</th>
<th>Subjects</th>
<th>Main result</th>
</tr>
</thead>
<tbody>
<tr>
<td>O’Neill et al. (2008)</td>
<td>Prospective cohort</td>
<td>6,814 Men and women aged 44–84 years who were free of clinical cardiovascular disease at baseline</td>
<td>Chronic and recent PM were not associated with current urinary albumin or microalbuminuria</td>
</tr>
<tr>
<td>Lue et al. (2013)</td>
<td>Quantitative study of</td>
<td>Confirmed acute ischemic stroke patients aged ≥21 years, residing in the Boston (MA, USA) metropolitan region between 1999 and 2004</td>
<td>Exposure associated with living near a major roadway contributed to reduced renal function (via the estimated glomerular filtration rate)</td>
</tr>
<tr>
<td>Mehta et al. (2016)</td>
<td>Prospective cohort</td>
<td>2,280 Male volunteers from the greater Boston area aged 21–80 years</td>
<td>Long-term PM$_{2.5}$ exposure negatively affected renal function and increased renal function decline (via the estimated glomerular filtration rate)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Design</th>
<th>Description</th>
<th>Findings</th>
</tr>
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<tbody>
<tr>
<td>Xu et al. (2016) [18]</td>
<td>Cross-sectional study</td>
<td>Renal biopsy series including 71,151 native biopsies at 938 hospitals spanning 282 cities in China between 2004 and 2014.</td>
<td>Long-term exposure to high levels of PM$_{2.5}$ was associated with an increased risk of membranous nephropathy.</td>
</tr>
<tr>
<td>Yang et al. (2017) [19]</td>
<td>Cross-sectional population-based study</td>
<td>21,656 Adults evaluated between 2007 and 2009 in New Taipei City who were participating in the Health Screening Program.</td>
<td>Exposure during the previous year to PM$<em>{10}$ and PMCoarse, but not PM$</em>{2.5}$, was associated with reduced renal function and chronic kidney disease.</td>
</tr>
<tr>
<td>Raaschou-Nielsen et al. (2011) [21]</td>
<td>Retrospective cohort study</td>
<td>54,304 Participants in the Danish Diet Cancer and Health cohort</td>
<td>Nitrogen oxides were weakly associated with kidney cancer, without statistical significance.</td>
</tr>
<tr>
<td>Raaschou-Nielsen et al. (2017) [20]</td>
<td>Retrospective cohort study</td>
<td>European Study of Cohorts for Air Pollution Effects included 14 cohorts of 289,002 participants, with at least 20 incident kidney parenchyma cancer cases during follow-up.</td>
<td>An increased risk of kidney cancer was associated with PM, although not to a statistically significant extent.</td>
</tr>
</tbody>
</table>
Standard level of criteria air pollutants and their sources with health impact based on the United States Environmental Protection Agency

<table>
<thead>
<tr>
<th>Air pollutants*</th>
<th>Major source of emission</th>
<th>Averaging time</th>
<th>Standard level</th>
<th>Health impact target organs</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{2.5}$</td>
<td>Motor engines, industrial activities, smokes</td>
<td>24 h</td>
<td>35 $\mu$g/m$^3$</td>
<td>Respiratory and cardiovascular diseases, CNS and reproductive dysfunctions, cancer</td>
</tr>
<tr>
<td>PM$_{10}$</td>
<td></td>
<td>24 h</td>
<td>150 $\mu$g/m$^3$</td>
<td></td>
</tr>
<tr>
<td>Ground-level ozone</td>
<td>Vehicular exhaust, industrial activities</td>
<td>1 h</td>
<td>0.12 mg/m$^3$</td>
<td>Respiratory and cardiovascular dysfunctions, eye irritation</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Motor engines, burning coal, oil and wood, industrial activities, smokes</td>
<td>1 h</td>
<td>35 mg/m$^3$</td>
<td>CNS and cardiovascular damages</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>Fuel combustion, burning coal</td>
<td>1 h</td>
<td>75 $\mu$g/m$^3$</td>
<td>Respiratory and CNS involvement, eye irritation</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>Fuel-burning, vehicular exhaust</td>
<td>1 h</td>
<td>100 $\mu$g/m$^3$</td>
<td>Damage to liver, lung, spleen, and blood</td>
</tr>
<tr>
<td>Lead</td>
<td>Lead smelting, industrial activities, leaded petrol</td>
<td>3 months average</td>
<td>0.15 $\mu$g/m$^3$</td>
<td>CNS and hematologic dysfunctions, eye irritation</td>
</tr>
<tr>
<td>Polycyclic aromatic hydrocarbons*</td>
<td>Fuel combustion, wood fires, motor engines</td>
<td>1 year</td>
<td>1 ng/m$^3$</td>
<td>Respiratory and CNS involvement, cancer</td>
</tr>
</tbody>
</table>

*Air quality standards according to the European Union; PM$_{2.5}$ is stand for PM of 2.5 $\mu$ or less. PM$_{10}$ is stand for PM of 10 $\mu$ or more. PM = Particulate matter, CNS = Central nervous system

## Number of deaths by risk factor, India, 2017

Total annual number of deaths by risk factor, measured across all age groups and both sexes.

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Deaths (2017)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High blood pressure</td>
<td>1.54 million</td>
</tr>
<tr>
<td>Air pollution (outdoor &amp; indoor)</td>
<td>1.24 million</td>
</tr>
<tr>
<td>Alcohol use</td>
<td>894,872</td>
</tr>
<tr>
<td>Smoking</td>
<td>818,803</td>
</tr>
<tr>
<td>Outdoor air pollution</td>
<td>580,499</td>
</tr>
<tr>
<td>Unsafe water source</td>
<td>69,679</td>
</tr>
<tr>
<td>Obesity</td>
<td>59,123</td>
</tr>
<tr>
<td>Indoor air pollution</td>
<td>52,131</td>
</tr>
<tr>
<td>Diet low in fruits</td>
<td>48,138</td>
</tr>
<tr>
<td>Low birth weight</td>
<td>32,870</td>
</tr>
<tr>
<td>No access to handwashing facility</td>
<td>257,784</td>
</tr>
<tr>
<td>Diet low in vegetables</td>
<td>253,455</td>
</tr>
<tr>
<td>Secondhand smoke</td>
<td>225,813</td>
</tr>
<tr>
<td>Child wasting</td>
<td>207,271</td>
</tr>
<tr>
<td>Low physical activity</td>
<td>174,896</td>
</tr>
<tr>
<td>Low bone mineral density</td>
<td>93,209</td>
</tr>
<tr>
<td>Unsafe sex</td>
<td>88,619</td>
</tr>
<tr>
<td>Vitamin-A deficiency</td>
<td>54,834</td>
</tr>
<tr>
<td>Drug use</td>
<td>33,283</td>
</tr>
<tr>
<td>Child stunting</td>
<td>45,425</td>
</tr>
<tr>
<td>Non-exclusive breastfeeding</td>
<td>33,415</td>
</tr>
<tr>
<td>Iron deficiency</td>
<td>15,245</td>
</tr>
<tr>
<td>Zinc deficiency</td>
<td>4,314</td>
</tr>
</tbody>
</table>

Source: IHME, Global Burden of Disease (GBD) CC BY

https://ourworldindata.org/air-pollution
NETWORK OF

PASSIONATE & INFORMED DOCTORS

LEADING THE FIGHT AGAINST AIR POLLUTION
DOCTORS FOR CLEAN AIR

KEY OBJECTIVES

AWARENESS

AMONG GENERAL PUBLIC
Doctors must educate the general public about the serious ill-effects of Air Pollution and the damage to their health and future generations due to breathing dirty air.

AWAKENING

FOR NEED FOR FASTER ACTION
Citizens and policy makers must realize the threat to mankind due to air pollution and recognize Air Pollution as a National Health Emergency.

COMMITMENT

BY CITIZENS & POLICY MAKERS
Doctors to influence Citizens, Administrators and Policy Makers for the need for urgent and stricter actions for Clean Air for their health.
DFCA is an initiative by
LUNG CARE FOUNDATION &
HEALTH CARE WITHOUT HARM

Lung Care Foundation
A not-for-profit organization
working towards “Care & Cure OF
2.6 Billion Lungs in India”
through education, research &
clinical care.

Healthcare Without Harm
Works to transform health care
worldwide so that it reduces its
environmental footprint,
becomes a community anchor
for sustainability and a leader in
the global movement for
environmental health and justice.
Clean Air Is A Human Right!
If We Don’t Act Today, Millions Die

www.dfca.org.in