



Health Impacts of Air Pollution

An Overview of Recent Research Studies



Air pollution was responsible for
7 million
premature deaths in 2016,
of these almost
600,000
were children under 5 years old.

BREATHELIFE
Clean Air. Healthy Future.



World Health
Organization



CLIMATE &
CLEAN AIR
COALITION
TO REDUCE SHORT-LIVED
CLIMATE POLLUTANTS

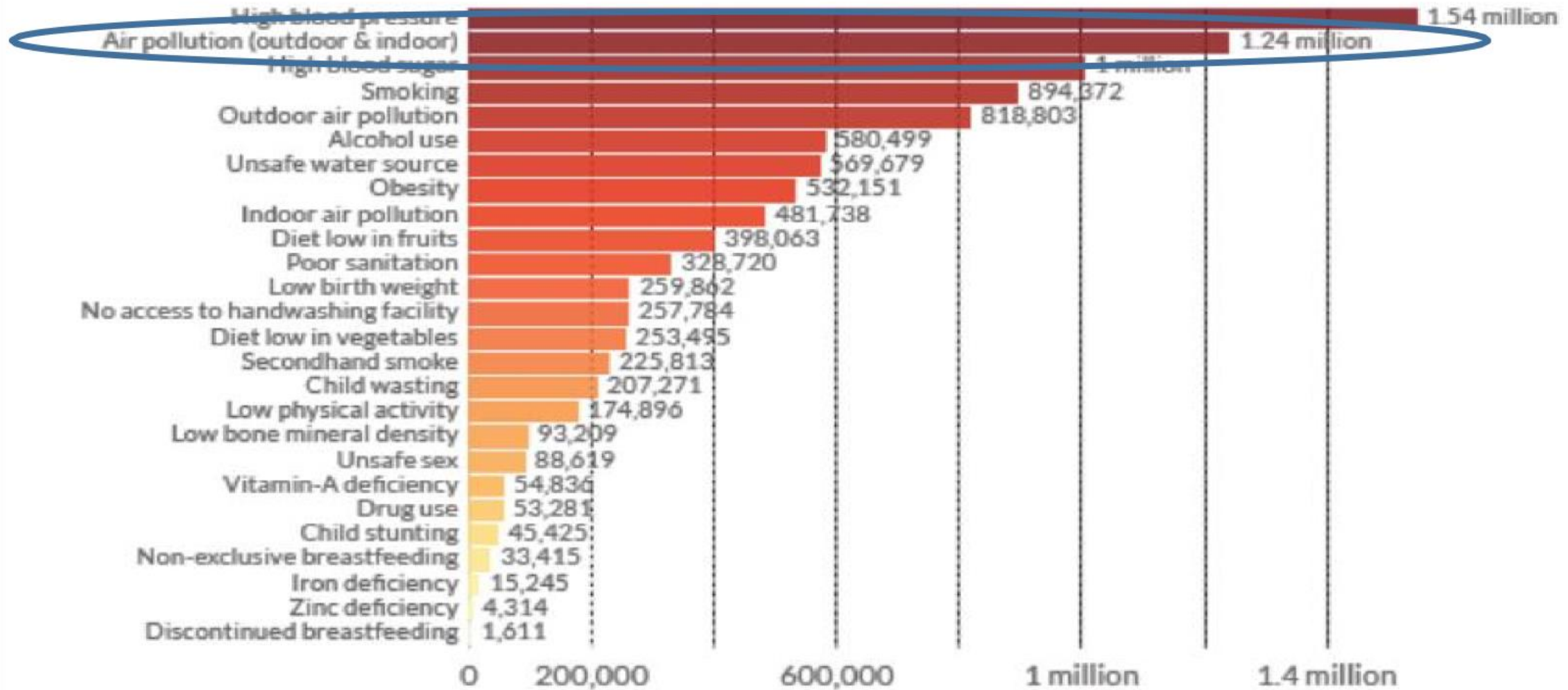
UN 
environment



In Polluted Cities, Breathing Kills!

Number of deaths by risk factor, India, 2017

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



Source: IHME, Global Burden of Disease (GBD)
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“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

* Source: WHO | Mortality and burden of disease from ambient air pollution [Internet]. WHO. [cited 2019 Nov 28].

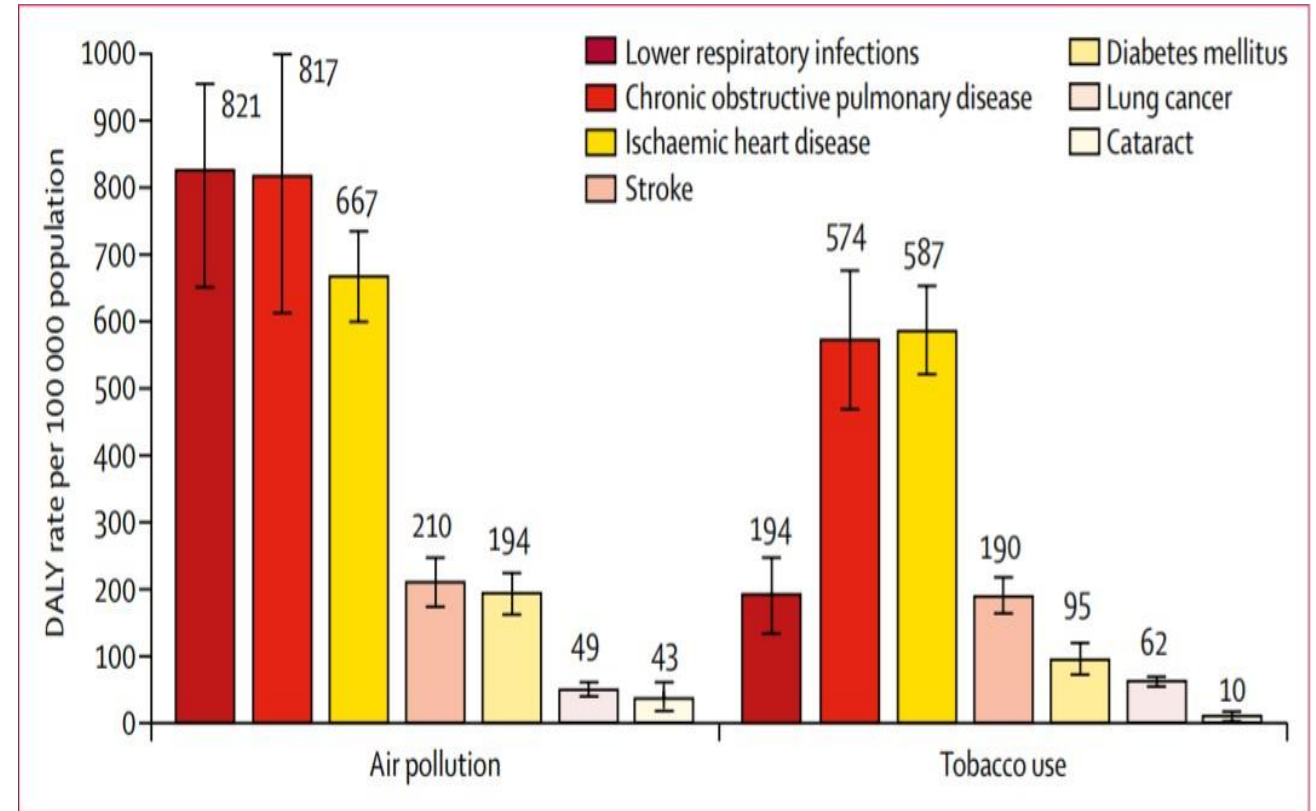
Available from: http://www.who.int/gho/phe/outdoor_air_pollution/burden_text/en/



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

The major proportions were from

- lower respiratory infections (29.3%),
- chronic obstructive pulmonary disease (29.2%),
- ischaemic heart disease (23.8%),
- stroke (7.5%),
- diabetes (6.9%),
- lung cancer (1.8%),
- cataract (1.5%)



DALY rates attributable to air pollution and tobacco use in India, 2017

Source: Balakrishnan K, Dey S, Gupta T, Dhaliwal RS, Brauer M, Cohen AJ, et al. The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study 2017. *The Lancet Planetary Health*. 2019 Jan;3(1):e26–39.

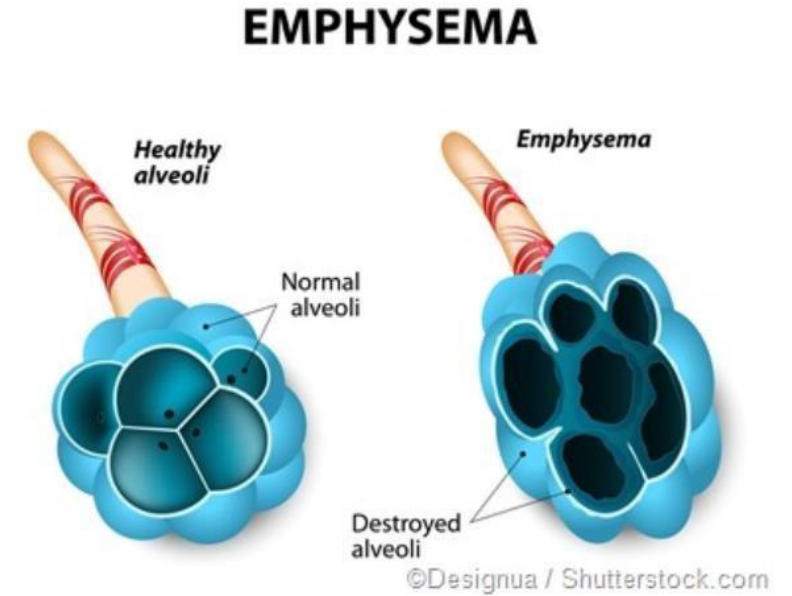
Available from: <https://www.thelancet.com/action/showPdf?pii=S2542-5196%02818%02930261-4>

Air Pollution &
Respiratory Effects



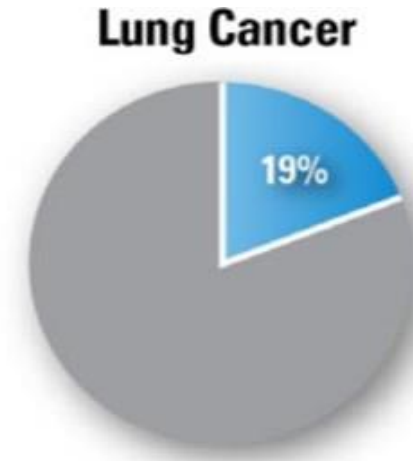
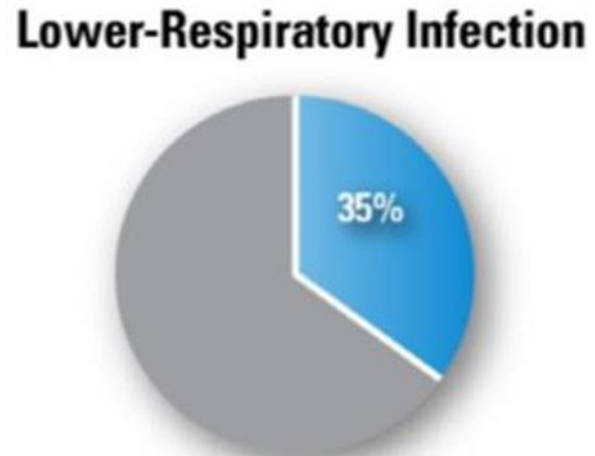
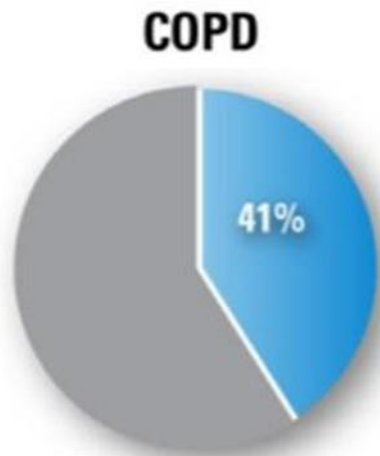
Air Pollution And Respiratory Effects

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



Source: <https://www.news-medical.net/health/Air-Pollution-and-Lung-Health.aspx>

Air pollution accounts for **41%** of global deaths from chronic obstructive pulmonary disease (COPD), **19%** of deaths from lung cancer, and **35%** of deaths from lower-respiratory infection



Study 1:

Pulmonary Health Effects of Air Pollution

(Kurt OK et al., 2016)

METHODOLOGY

A total of 53 publications were reviewed to examine the health effects of specific air pollutants

RESULTS

ASTHMA

- Long-term exposure associated with a number of adverse effects, such as **wheezing, cough or phlegm**
- Exposure in early childhood to traffic-related air pollution (TRAP) **increased incidence of asthma** up to the age of 12 years
- Long-term exposure to TRAP **increased risk of asthma, allergic sensitization and decreased lung function** in schoolchildren

COPD

- **10 $\mu\text{g}/\text{m}^3$ increase** of PM10 in outdoor air can induce **significant acute exacerbations** of and **mortality** from COPD

LUNG CANCER

- Ambient exposure to nitrogen oxides, SO₂, and PM2.5 from vehicle emissions significantly **increases the risk** of lung cancer
- Professional drivers exposed to **diesel engine** exhaust have an **elevated risk** of lung cancer

CONCLUSIONS

Air pollution is an important contributor to respiratory complications

Study 2:

Air pollution, weather, and associated risk factors related to
asthma prevalence and attack rate

(Ho WC et al., 2007)

Source: Ho WC, Hartley WR, Myers L, Lin MH, Lin YS, Lien CH, et al. Air pollution, weather, and associated risk factors related to asthma prevalence and attack rate. Environ Res. 2007 Jul;104(3):402-9.

Available from: <https://www.ncbi.nlm.nih.gov/pubmed/17316602>

OBJECTIVE

To investigate the relationship of air pollution and weather to adolescent asthma prevalence and attack rate

METHODOLOGY

A stratified random sample of 64,660 students, aged 10-17 years was analyzed from October 1995 to March 1996 in Taiwan

RESULTS

ASTHMA PREVALENCE

- **Males** had **higher** asthma prevalence than females
- **Younger** age groups had **higher** asthma prevalence than older age groups
- Average **0.4% lower prevalence** than overall population (both males and females)

ATTACK RATE

- Nitrogen oxides, Ozone and PM10 were related to asthma attack rate
- Sulphur dioxide showed a reversal effect on monthly asthma attack rate

CONCLUSIONS

The study demonstrated that air pollution is related to asthma attack rate

Study 3:

Outdoor air pollution and lung cancer: Recent epidemiologic Evidence

(Vineis P et al., 2004)

OBJECTIVE

To explore the health impacts of particulate and gaseous emissions from diesel and gasoline exhaust

RESULTS

- 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
 - Found approximately **19% increase in risk per 10 $\mu\text{g}/\text{m}^3$**
- 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 (NO_2 and SO_2).
 - Found a **risk ratio of 1.08** for an increment of 10 $\mu\text{g}/\text{m}^3$ of NO_2
- In a large case-control study in Trieste, Italy, residence in the polluted city center was associated with **increased risks of small cell** (RR // 2.0, 95% CI 1.2–3.4) and **large cell** (RR // 2.6, 95% CI 1.2–5.3) **lung cancer** relative to residence in a suburban area

CONCLUSIONS

High levels of ambient air pollution poses considerable burden of cardio-respiratory diseases



Study 4:

Effects of particulate air pollution on the respiratory health of subjects who live in three areas in Kanpur, India

(Sharma M et al., 2004)

Source: Sharma M, Kumar VN, Katiyar SK, Sharma R, Shukla BP, Sengupta B. Effects of particulate air pollution on the respiratory health of subjects who live in three areas in Kanpur, India. Arch Environ Health. 2004 Jul;59(7):348–58.

Available from:

https://www.researchgate.net/publication/7525600_Effects_of_Part particulate_Air_Pollution_on_the_Respiratory_Health_of_Subjects_Who_Live_in_Three_Areas_in_Kanpur_India

OBJECTIVE

To assess the relationship between daily changes in respiratory health and PM10 and PM2.5 in Kanpur

METHODOLOGY

Subjects (N = 91) were recruited from 3 areas in Kanpur, residing near air quality monitoring sites
Air quality and peak expiratory flow rate samplings were conducted for 39 days
Lung-function tests were performed on each subject

RESULTS

- Participants residing at **clean site performed better** more often than the participants who lived at the remaining two sites
- **PM10** showed a **stronger association** with lung function than PM2.5
- An increase of $100 \mu\text{g}/\text{m}^3$ of the pollutant PM10 could reduce the mean peak expiratory flow rate of an individual by approximately **3.2 l/min**

CONCLUSIONS

Particulate matter is associated with adverse respiratory health effects



Study 5:

Outdoor air pollution and emergency room visits at a hospital in Delhi

(Pande JN et al., 2002)

Source: Pande JN, Bhatta N, Biswas D, Pandey RM, Ahluwalia G, Siddaramaiah NH, et al. Outdoor air pollution and emergency room visits at a hospital in Delhi. *Indian J Chest Dis Allied Sci.* 2002 Mar;44(1):13–9.

Available from: <http://www.indiaenvironmentportal.org.in/files/Outdoor%20air%20pollution.pdf>

OBJECTIVE

To correlate the daily levels of various pollutants with the number of patients visiting AIIMS, New Delhi casualty for aggravation of cardio-respiratory disorders

METHODOLOGY

Patient records scrutinized for casualty visits from January, 1997 to December, 1998

Events of Interest: Acute exacerbation of chronic obstructive airways disease (COAD), acute asthmatic attack, and acute coronary event

Data for air pollutants obtained from Central Pollution Control Board

RESULTS

- Cardio-respiratory events were **significantly and positively correlated** with all pollutants measured
- Visits for COAD, acute coronary events, and asthma increased by **24.90%**, **24.30%** and **21.30%** respectively
- Casualty visits **increased sharply** in November and December when level of pollutants was also high
- Out of that, **one-fourth (of average 22 daily events recorded)** is estimated to be attributable to pollutant levels

CONCLUSIONS

High levels of ambient air pollution poses considerable burden of cardio-respiratory diseases

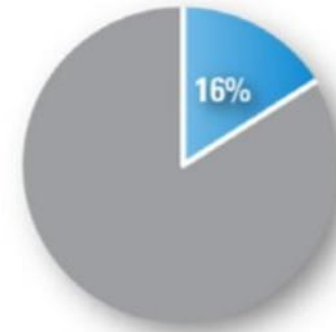
Air Pollution &
Cardiovascular Effects



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

Ischemic Heart Disease



Stroke



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

Source: Bourdrel T, Bind M-A, Bejot Y, Morel O, Argacha J-F. Cardiovascular effects of air pollution. Archives of Cardiovascular Diseases. 2017 Nov;110(11):634–42.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5963518/pdf/nihms949393.pdf>

Source*: Health Effects Institute. 2019. State of Global Air 2019. Special Report. Boston, MA: Health Effects Institute.

Available from: https://www.stateofglobalair.org/sites/default/files/soga_2019_report.pdf

Study 1:

Association between ambient and household air pollution with carotid intima-media thickness in peri-urban South India: CHAI-Project

(Ranzani OT et al., 2019)

Source: Ranzani OT, Mila C, Sanchez M, Bhogadi S, Kulkarni B, Balakrishnan K, et al. Association between ambient and household air pollution with carotid intima-media thickness in peri-urban South India: CHAI-Project. *International Journal of Epidemiology*. 2019 Oct 11;dyz208.

Available from: <https://academic.oup.com/ije/advance-article/doi/10.1093/ije/dyz208/5585954>

OBJECTIVE

To evaluate the association between ambient fine particulate matter and biomass fuel use on carotid intima-media thickness (CIMT), a surrogate of atherosclerosis

METHODOLOGY

Data from the third follow-up of Andhra Pradesh Children and Parent Study (n=6944) was obtained
Annual ambient concentration of PM_{2.5} at residence was estimated using a land-use regression (LUR) area model

RESULTS

PM_{2.5}

- **Positive associations** was found with CIMT in the whole population (1.79%, 95% CI, 0.31, 3.90, per 1 mg/m³ of PM_{2.5})
- Association was primarily driven by **men**

BIOMASS FUEL

- **Positive, but imprecise, association** of biomass compared with clean fuel (1.60%, 95% CI, 0.46–3.65) in the whole population
- **Larger** association found **among women** with an unvented stove (6.14%, 95% CI, 1.40–10.89)

CONCLUSIONS

Ambient and household air pollution were positively associated with CIMT in a peri-urban population of India

Study 2:

Long term exposure to ambient air pollution and incidence of acute coronary events: prospective cohort study and meta-analysis in 11 European cohorts from the ESCAPE Project

(Cesaroni G et al., 2014)

Source: Cesaroni G, Forastiere F, Stafoggia M, Andersen ZJ, Badaloni C, Beelen R, et al. Long term exposure to ambient air pollution and incidence of acute coronary events: prospective cohort study and meta-analysis in 11 European cohorts from the ESCAPE Project. *BMJ* [Internet]. 2014 Jan 21 [cited 2019 Nov 29];348.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3898420/>

OBJECTIVE

To study the effect of long term exposure to airborne pollutants on the incidence of acute coronary events

METHODOLOGY

Prospective cohort study people (n=1,00,166) were enrolled from 1997 to 2007 and followed for an average of 11.5 years
Location: Cohorts in Finland, Sweden, Denmark, Germany, and Italy

RESULTS

PM_{2.5}

- 5 $\mu\text{g}/\text{m}^3$ increase in estimated annual mean PM_{2.5} was associated with a **13% increased risk** of coronary events
- **Stronger PM_{2.5}** effects for those **aged 60-74** (hazard ratio 1.25) and for those **>75** (1.18) than among those aged under 60 (0.91)

PM₁₀, NO₂

- 10 $\mu\text{g}/\text{m}^3$ increase in estimated annual mean **PM₁₀** was associated with a **12% increased risk** of coronary events (strongest association)
- Only **small positive** associations were found for **nitrogen oxides**

CONCLUSIONS

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

Study 3:

Global association of air pollution and heart failure: a systematic review and meta-analysis

(Shah AS et al., 2013)

Source: Shah AS, Langrish JP, Nair H, McAllister DA, Hunter AL, Donaldson K, et al. Global association of air pollution and heart failure: a systematic review and meta-analysis. *The Lancet*. 2013 Sep;382(9897):1039–48.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3809511/>

OBJECTIVE

To assess the association between air pollution and acute decompensated heart failure including hospitalization and heart failure mortality

METHODOLOGY

Of 1146 identified articles from five databases, 195 articles were reviewed in-depth and 35 articles were subsequently selected as per inclusion criteria

RESULTS

- **Positive association** between heart failure hospitalisation or heart failure mortality and all gaseous and particulate air pollutants except ozone
- Carbon monoxide (CO) showed a **3.52% increase in heart failure hospitalisations** or mortality per 1 part per million increment
- Both **PM_{2.5} (2.12%, 95% CI 1.42–2.82)** and **PM₁₀ (1.63%, 1.20–2.07)** were **positively associated** with heart failure hospitalisation or mortality with a marked temporal relation
- **Strongest associations** were seen on the **day of exposure**, with more persistent effects for PM_{2.5}
- A mean reduction in PM_{2.5} of **3.9 µg/m³ can prevent 7978 heart failure hospitalisations**

CONCLUSIONS

Robust and clear temporal associations between exposure to air pollutants and heart failure hospitalisations and mortality found



Study 4:

Long-term air pollution exposure and cardio-respiratory mortality: a review

(Hoek G et al., 2013)

Source: Hoek G, Krishnan RM, Beelen R, Peters A, Ostro B, Brunekreef B, et al. Long-term air pollution exposure and cardio-respiratory mortality: a review. Environ Health. 2013 Dec;12(1):43.

Available from: <https://ehjournal.biomedcentral.com/track/pdf/10.1186/1476-069X-12-43>

OBJECTIVE

To summarize the evidence on long-term exposure to fine and coarse particles, nitrogen dioxide (NO₂) and elemental carbon on mortality from all-causes, cardiovascular disease and respiratory disease

METHODOLOGY

Identified studies through a search in the databases Medline and Scopus until January 2013 and performed a meta analysis if more than five studies were available

RESULTS

- **Excess risk** per 10 µg/m³ increase in PM_{2.5} exposure was **6%** for all-cause and **11%** for cardiovascular mortality
- Long-term exposure to **PM_{2.5} was more associated** with mortality from **cardiovascular disease** (particularly ischemic heart disease)
- **All-cause mortality** was significantly associated with **elemental carbon** (per 1 µg/m³ **6%**) and **NO₂** (per 10 µg/m³ **5%**)
- Little evidence for an association between long term coarse particulate matter exposure and mortality, possibly due to the small number of studies

CONCLUSIONS

Several studies link the association of air pollution with cardiovascular and respiratory diseases

Study 5:

A 10-year time-series analysis of respiratory and cardiovascular morbidity in Nicosia, Cyprus: the effect of short-term changes in air pollution and dust storms

(Middleton N et al., 2008)

Source: Middleton N, Yiallourous P, Kleanthous S, Kolokotroni O, Schwartz J, Dockery DW, et al. A 10-year time-series analysis of respiratory and cardiovascular morbidity in Nicosia, Cyprus: the effect of short-term changes in air pollution and dust storms. *Environ Health*. 2008 Jul 22;7(39):1–16.

Available from: <https://ehjournal.biomedcentral.com/track/pdf/10.1186/1476-069X-7-39>

OBJECTIVE

To investigate associations between daily levels of (a) PM10 and (b) ozone (O₃) on counts of hospital admissions for all respiratory and cardiovascular causes

METHODOLOGY

Hourly measurements of PM10 and O₃ were available from two ambient air quality monitoring stations
All cardiovascular and respiratory admissions between 1 January 1995 to 30 December 2004 were obtained

RESULTS

PM10

- **10 µg/m³ increase** in daily average **PM10** was associated with a **0.9% increase** in all-cause and **1.2% increase** in cardiovascular admissions
- An effect was observed only in the **warm months** for respiratory causes

OZONE & DUST

- Positive associations with ozone observed **the two days prior to admission**
- Association was **stronger for cardiovascular causes** and independent of the effect of PM
- All-cause and cardiovascular admissions were **4.8% and 10.4% higher on dust storm days** respectively

CONCLUSIONS

Increased risk of hospitalization at elevated levels of particulate matter and ozone and on dust storm days, particularly for cardiovascular causes

*Air Pollution &
Reproductive & Neonatal Effects*

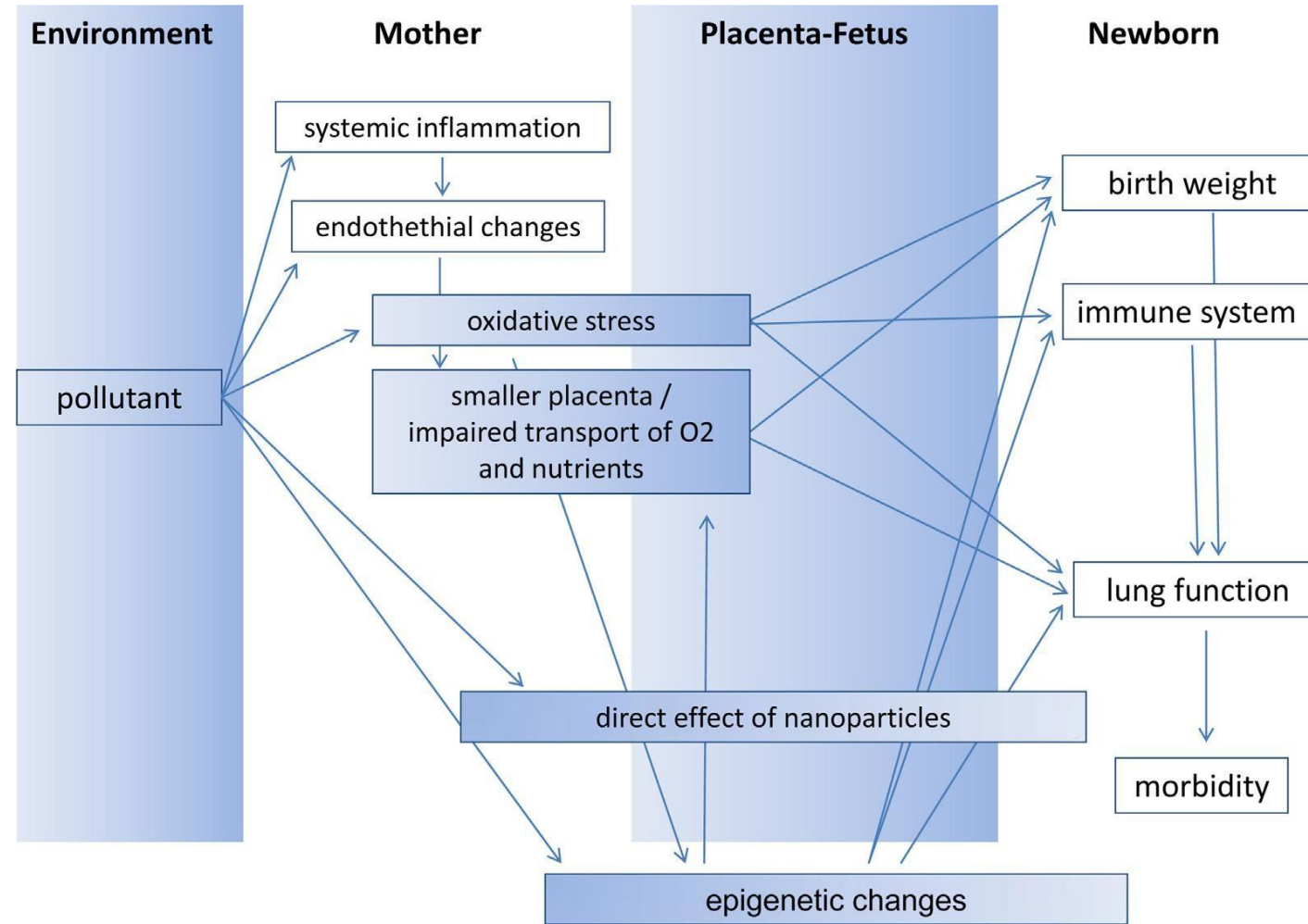


Air Pollution And Reproductive And Neonatal Health

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



Direct And Indirect Impact Of Air Pollution In Pregnancy On Adverse Birth Outcomes And Lung Development



Study 1:

Association of Air Pollution and Heat Exposure With Preterm Birth, Low Birth Weight, and Stillbirth in the US A Systematic Review

(Bekkar et al., 2020)

Source: Bekkar, B., Pacheco, S., Basu, R., & DeNicola, N. (2020). Association of Air Pollution and Heat Exposure With Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. *JAMA Network Open*, 3(6), e208243-e208243.

Available from: <https://jamanetwork.com/journals/jamanetworkopen/article-abstract/2767260>

METHODOLOGY

Of the 1851 studies published from January 1, 2007, to April 30, 2019, on US populations, **68 articles** were included according to the study criteria. A total of **32 million births** were analysed.

RESULTS

PRETERM BIRTH RISK

- **79%** (19/24) studies found an **increased risk**
- Median increase in risk - **11.5%** (range, 2%-19%)
- Risk **increased 52% for asthmatic mothers**

LOW BIRTH WEIGHT RISK

- **86%** (25/29) studies found an **increased risk of 10.8%** (range 2%-36%)
- **3% increased risk for each 5 km** nearer residence to solid waste plant emitting PM2.5

STILLBIRTH

- **80%** (4/5) studies found an increased risk of **14.5%** (6%-23%)
- **42% increased risk** (95% CI, 6%-91%) of stillbirth associated with high exposure during the **third trimester**

CONCLUSIONS

84% of studies found significant positive associations between exposure to PM2.5 and ozone and adverse pregnancy outcomes

Study 2:

Association between air pollution and menstrual disorder outpatient visits: A time-series analysis

(Liang et al., 2020)

Source: Liang, Z., Xu, C., Fan, Y. N., Liang, Z. Q., Kan, H. D., Chen, R. J., ... & Zhao, Y. S. (2020). Association between air pollution and menstrual disorder outpatient visits: A time-series analysis. *Ecotoxicology and Environmental Safety*, 192, 110283.

Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0147651320301226>

METHODOLOGY

Data of daily outpatient visits for menstrual disorders from January 1, 2010 to February 18, 2016 (2239 days) collected
Daily (24-h) average concentrations of air pollutants, including PM10, SO₂, and NO₂ gathered

RESULTS

OUTPATIENTS

- 51,893 cases of menstrual disorders recorded
- On average, **22.98** outpatients were admitted per day
- Young adults (18–29 years old) accounted for **41.64%**

PM10

- **10 µg/m³ increase** of PM10 corresponded to **0.236%** (lag 7-95% CI: 0.075%, 0.397%) **elevations** in outpatient-visits
- Association was **only significant in young females** (18–29 years)

NO₂

- **10 µg/m³ increase** of NO₂ corresponded to **2.173%** (lag 01-95% CI: 0.990%, 3.357%) **elevations** in outpatient-visits
- Association was **significant for 18–29 years** and **30-39 year-old** age groups

CONCLUSIONS

First evidence that short-term exposure to air pollutants can be associated with an increased risk of outpatient-visits for menstrual disorders



Study 3:

Exposures to fine particulate matter (PM_{2.5}) and birthweight
in a rural-urban, mother-child cohort in Tamil Nadu, India

(Balakrishnan K et al., 2018)

Source: Balakrishnan K, Ghosh S, Thangavel G, Sambandam S, Mukhopadhyay K, Puttaswamy N, et al. Exposures to fine particulate matter (PM_{2.5}) and birthweight in a rural-urban, mother-child cohort in Tamil Nadu, India. *Environmental Research*. 2018 Feb 1;161:524–31.

Available from: <https://www.ncbi.nlm.nih.gov/pubmed/29227900>

OBJECTIVE

To examine whether PM_{2.5} exposures during pregnancy were associated with birth weight

METHODOLOGY

1285 pregnant women were recruited in the first trimester of pregnancy and followed them until birth to collect ANC data and birth weight

Estimation of pregnancy period PM_{2.5} exposures performed across each trimester

RESULTS

- A 10 µg/m³ increase in pregnancy period **PM_{2.5}** exposures was associated with a **4g decrease in birth weight** (95% CI: 1.08 g, 6.76 g)
- The study also estimates **2% increase in low birth-weight** per 10-µg/m³ increase in **PM_{2.5}** exposures (OR = 1.02; 95% CI: 1.005,1.041)

CONCLUSIONS

First quantitative effects estimates for linking rural-urban PM_{2.5} exposures and birthweight in India



Study 4:

The relationship between exposure to air pollution and sperm disomy

(Jurewicz J et al., 2015)

Source: Jurewicz J, Radwan M, Sobala W, Polańska K, Radwan P, Jakubowski L, et al. The relationship between exposure to air pollution and sperm disomy. *Environ Mol Mutagen.* 2015 Jan;56(1):50–9.

Available from: <https://www.ncbi.nlm.nih.gov/pubmed/24989325>

OBJECTIVE

To test the hypothesis that exposure to specific air pollutants increases sperm disomy

METHODOLOGY

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

RESULTS

- **Positive associations** were observed between exposure to PM_{2.5} 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 PM_{2.5} and disomy Y and disomy 21 remained **significant**

CONCLUSIONS

First findings indicate that exposure to air pollution induces sperm aneuploidy

Study 5:

Air pollution and human fertility rates

(Nieuwenhuijsen MJ et al., 2014)

Source: Nieuwenhuijsen MJ, Basagana X, Dadvand P, Martinez D, Cirach M, Beelen R, et al. Air pollution and human fertility rates. *Environment International*. 2014 Sep;70:9–14.

Available from: <https://www.rtihs.org/sites/default/files/29228%20Martinez%202014%20Air%20pollution%20and%20human%20fertility%20rates.pdf>

OBJECTIVE

To assess the association between traffic related air pollution and fertility rates in humans in Barcelona

METHODOLOGY

A general fertility rate was calculated for women between the ages of 15 and 44 years per census tract
Land use regression (LUR) modeling used to estimate the air pollution concentrations (particulate matter, NO₂/NO_x) per census tract

RESULTS

- **Fertility rates declined** with increasing air pollution levels after adjusting for covariates
- Statistically significant reduction of fertility rates was observed only with **coarse fraction of particulate matter** (IRR = 0.87 95% CI 0.82, 0.94 per IQR)

CONCLUSIONS

First study in humans which showed an association between reduced fertility rates and higher traffic related air pollution levels



Study 6:

The impact of polycyclic aromatic hydrocarbons and fine particles on pregnancy outcome

(Dejmek J et al., 2000)

Source: Dejmek J, Solansky I, Benes I, Leníček J, Sram RJ. The impact of polycyclic aromatic hydrocarbons and fine particles on pregnancy outcome. *Environ Health Perspect.* 2000 Dec;108(12):1159–64.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240197/pdf/ehp0108-001159.pdf>

OBJECTIVE

To analyse the impact of polycyclic aromatic hydrocarbons (c-PAHs) on Intrauterine growth retardation (IUGR)

METHODOLOGY

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

RESULTS

- The OR of IUGR for fetuses exposed to medium levels of c-PAHs in the first GM was **1.60** [CI, 1.06–2.15], and to high levels **2.15** (CI, 27–3.63)
- 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)

CONCLUSIONS

Exposure to c-PAHs in early gestation may influence fetal growth



Study 7:

Fetal growth and maternal exposure to particulate matter
during pregnancy

(Dejmek J et al., 1999)

Source: Dejmek J, Selevan SG, Benes I, Solansky I, Sram RJ. Fetal growth and maternal exposure to particulate matter during pregnancy. *Environ Health Perspect.* 1999 Jun;107(6):475–80.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1566587/pdf/envhper00511-0091.pdf>

OBJECTIVE

To examine the possible impact of PM10 and PM2.5 on intrauterine growth retardation (IUGR) risk

METHODOLOGY

Study group includes all singleton full-term births over a 2-year period in a highly polluted area of Northern Bohemia
Study included 1,943 women who gave birth to infants between 37 and 43 gestational weeks

RESULTS

PM10

- PM10 was associated with **increase in IUGR**
- Both medium (40-50 $\mu\text{g}/\text{m}^3$) and high exposures ($\geq 50 \mu\text{g}/\text{m}^3$) were **statistically significant** for
 - Medium level OR : 1.62 (CI, 1.07-2.46)
 - High level OR : 2.64 (CI, 1.48-4.71)

PM2.5

- PM2.5 was associated with **increase in IUGR**
 - Medium level (27-37 $\mu\text{g}/\text{m}^3$) ORs were 1.26 (0.81-1.95)
 - High level ($\geq 37 \mu\text{g}/\text{m}^3$) ORs were 2.11 (1.20-3.70) – **only statistically significant**

CONCLUSIONS

Exposure to particulate matter (or an associated air pollutant) early in pregnancy may adversely affect fetal growth

Air Pollution &
Gastrointestinal Effects



Air Pollution And Gastrointestinal Effect

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

Study 1:

Ambient air pollution correlates with hospitalizations for inflammatory bowel disease: an ecologic analysis

(Ananthakrishnan AN et al., 2011)

Source: Ananthakrishnan AN, McGinley EL, Binion DG, Saeian K. Ambient air pollution correlates with hospitalizations for inflammatory bowel disease: an ecologic analysis. *Inflamm Bowel Dis*. 2011 May;17(5):1138–45.

Available from: <https://www.ncbi.nlm.nih.gov/pubmed/20806342>

OBJECTIVE

To evaluate the association between ambient air pollution and inflammatory bowel disease (IBD) hospitalizations

METHODOLOGY

Data for the year 2002 was used to identify the number of IBD-related hospitalizations
Average annual emissions density for each of the six criteria pollutants were obtained

RESULTS

- Mean of 81.3 IBD hospitalizations/100,000 population per county
- Total criteria pollutant emissions density **correlated significantly** with adult IBD hospitalizations (Pearson's correlation coefficient (rho) 0.28, P = 0.02)
- 1-log increase in the density of total criteria pollutant emission was associated with a **40% increase in the rate** of IBD hospitalizations (incidence rate ratio [IRR] 1.40, 95% [CI] 1.31-1.50)
- Similar **increase** in hospitalizations seen with **ulcerative colitis** (UC) (IRR 1.48, 95% CI 1.27-1.73) and Crohn's disease (CD) (IRR 1.39, 95% CI 1.26-1.52)

CONCLUSIONS

Total air emissions of criteria pollutants appear to be associated with hospitalizations for IBD in adults



Study 2:

The inflammatory bowel diseases and ambient air pollution: a novel association

(Kaplan GG et al., 2010)

Source: Kaplan GG, Hubbard J, Korzenik J, Sands BE, Panaccione R, Ghosh S, et al. The inflammatory bowel diseases and ambient air pollution: a novel association. *Am J Gastroenterol*. 2010 Nov;105(11):2412–9.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3180712/pdf/ajg2010252a.pdf>

OBJECTIVE

To study whether ambient air pollution levels are associated with the incidence of inflammatory bowel disease (IBD)

METHODOLOGY

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.

RESULTS

- Overall NO₂, SO₂, and PM10 were **not associated** with the risk of IBD
- Individuals **≤23 years were more likely** to be diagnosed with **Crohn's disease** if they lived in regions with NO₂ concentrations within the upper three quintiles (OR = 2.31; 95 % CI = 1.25– 4.28)

CONCLUSIONS

Air pollution exposure was not associated with the incidence of IBD

However, residential exposures to SO₂ and NO₂ may increase the risk of early-onset ulcerative colitis and Crohn's disease, respectively

Study 3:

Effect of ambient air pollution on the incidence of appendicitis
(Kaplan GG et al., 2009)

Source: Kaplan GG, Dixon E, Panaccione R, Fong A, Chen L, Szyszkowicz M, et al. Effect of ambient air pollution on the incidence of appendicitis. CMAJ. 2009 Oct 27;181(9):591-7.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2764754/pdf/1810591.pdf>

OBJECTIVE

To determine whether short-term increases in concentrations of selected air pollutants were associated with hospital admission because of appendicitis

METHODOLOGY

A case–crossover study design where 5191 adults who had been admitted to hospital with appendicitis between Apr. 1, 1999 and Dec. 31, 2006 were identified

The air pollutants studied were O₃, NO₂, SO₂, CO, and PM₁₀ and PM_{2.5}

RESULTS

- An increase in the interquartile range of the 5- day average of ozone was **associated with appendicitis** (OR 1.14, 95% CI 1.03–1.25)
- In summer (July–August), the effects were most pronounced for
 - Nitrogen dioxide (OR 1.76, 95% CI 1.20–2.58),
 - Carbon monoxide (OR 1.35, 95% CI 1.01–1.80)
 - Ozone (OR 1.32, 95% CI 1.10–1.57),
 - Sulfur dioxide (OR 1.30, 95% CI 1.03–1.63), and
 - PM₁₀ (OR 1.20, 95% CI 1.05–1.38)

CONCLUSIONS

Some cases of appendicitis may be triggered by short-term exposure to air pollution

Air Pollution &
Effects on **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



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

Source: Costa LG, Cole TB, Coburn J, Chang Y-C, Dao K, Roque P. Neurotoxicants Are in the Air: Convergence of Human, Animal, and *In Vitro* Studies on the Effects of Air Pollution on the Brain. *BioMed Research International*. 2014;2014:1–8.

Available from: <http://downloads.hindawi.com/journals/bmri/2014/736385.pdf>

Study 1:

Declines in mental health associated with air pollution and temperature variability in China

(Tao Xue et al., 2019)

Source: Tao Xue, Tong Zhu, Yixuan Zheng, Qiang Zhang, Declines in mental health associated with air pollution and temperature variability in China , Nature Communications (2019).

Available from: <https://www.nature.com/articles/s41467-019-10196-y>

OBJECTIVE

To explore an association between multiple environment factors and self-assessed mental health scores

METHODOLOGY

Mental health scores of over 20,000 Chinese residents were surveyed in 2010 and 2014 to develop a link between changes in mental health and changes in environmental variables

RESULTS

- Around **40% adults** reported poor mental health
- **Weak association** though insignificant was found between the mean temperature and mental health
- 1 degree Celsius increase in mean temperature resulted in a **3% decrease in mental health scores** (MHS)
- Every 0.05 decrease in NDVI increases the risk of MHS **decrease by 19%**
- A 10 $\mu\text{g}/\text{m}^3$ increase in PM2.5 levels showed a **28% decrease** in the mental health scores

CONCLUSIONS

A reduction in emissions of air pollution and greenhouse gases can improve mental health of the people

Study 2:

Exposure to traffic related air pollution in pregnancy and infancy in relation to autism spectrum disorder in California

(O von Ehrenstein et al., 2019)

Source: O von Ehrenstein, H, Aralis, X, Cui, J, Wu, L, Li, M, Cockburn, B, Ritz, Exposure to traffic related air pollution in pregnancy and infancy in relation to autism spectrum disorder in California, International Society for Environmental Epidemiology (2019).

Available from: https://journals.lww.com/environepidem/Fulltext/2019/10001/Exposure_to_traffic_related_air_pollution_in.1271.aspx

OBJECTIVE

To conduct a state wide study in California to find the road traffic related exposure during pregnancy and childhood Autism Spectrum Disorder (ASD)

METHODOLOGY

State-wide California birth data was retrieved for the years 1998 to 2010

A total of 30,514 ASD cases were identified and linked to birth records

The exposure to road traffic related pollutants during the pregnancy and first year of life were estimated

RESULTS

- Exposure to interquartile-range increases of the correlated pollutants CO, NO_x and PM_{2.5} related to **increased ORs for ASD of 10-13%** for prenatal and similarly for infant exposure
- Potentially stronger associations were noticed for infant exposure when included prenatal and infant exposure

CONCLUSIONS

Small to moderate increase in risks for ASD was found related to pregnancy and early life exposure to traffic generated air pollution

Study 3:

Effect of long-term exposure to air pollution on anxiety and depression in adults: A cross-sectional study

(Vert et al., 2017)

Source: Vert C, Sánchez-Benavides G, Martínez D, et al. Effect of long-term exposure to air pollution on anxiety and depression in adults: a cross-sectional study. *Int J Hyg Environ Health*. 2017 Aug;220(6):1074-1080. doi: 10.1016/j.ijheh.2017.06.009.

Available from: <https://www.sciencedirect.com/science/article/abs/pii/S1438463917302973?via%3Dihub>

OBJECTIVE

To analyze the association between long-term exposure to air pollution and history of anxiety and depression disorders and of medication use (benzodiazepines and antidepressants) in adults

METHODOLOGY

958 adults (45–74 years old) residents were included

Land Use Regression (LUR) models to estimate long-term residential exposure (period 2009–2014) to pollutants

RESULTS

- **Increased odds** of history of depression disorders with increasing concentrations of all air pollutants was found
- For each 10 $\mu\text{g}/\text{m}^3$ NO_2 increase, an **increased odds of depression of 2.00** (95% CI; 1.37, 2.93) was observed
- Higher concentrations of air pollutants also **increased odds of medication use**
- For each 20 $\mu\text{g}/\text{m}^3$ NO_x increase, **increased odds of antidepressants use of 1.23** (1.04, 1.44) was seen

CONCLUSIONS

Increasing long-term exposure to air pollution may increase the odds of depression and the use of antidepressants and benzodiazepines

Study 4:

Air Pollution and Emergency Department Visits for Depression: A Multicity Case-Crossover Study

(Szyszkowicz M et al., 2016)

Source: Szyszkowicz M, Kousha T, Kingsbury M, Colman I. Air Pollution and Emergency Department Visits for Depression: A Multicity Case-Crossover Study.

Environmental Health Insights. 2016 Jan;10:155–61

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5006648/pdf/ehi-10-2016-155.pdf>

OBJECTIVE

To investigate the associations between ambient air pollution and emergency department (ED) visits for depression

METHODOLOGY

A case-crossover design was employed

Data were retrieved from the National Ambulatory Care Reporting System (NACRS)

The environmental data were obtained from Environment Canada

RESULTS

- The total number of ED visits for depression identified in this study was 118,602 (most for age group 16-25 yrs)
- Per 14.5 ppb increase of O₃, **increased risk of an ED visit for depression** in both females and males was found
- For females, association with ozone was found 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
- Increased **SO₂** (per 2.5 ppb) was also associated with **increased risk for females** seven days after exposure
- Exposure to **PM2.5** was associated with **increased risk one day after exposure for males**

CONCLUSIONS

There is a positive association between exposure to air pollution and ED visits for depression

Study 5:

Neurotoxicants are in the Air: Convergence of Human, Animal and In Vitro Studies on the Effects of Air Pollution on the Brain

(Costa LG et al., 2014)

Source: Costa LG, Cole TB, Coburn J, Chang Y-C, Dao K, Roque P. Neurotoxicants Are in the Air: Convergence of Human, Animal, and In Vitro Studies on the Effects of Air Pollution on the Brain. *BioMed Research International*. 2014;2014:1–8.

Available from: <http://downloads.hindawi.com/journals/bmri/2014/736385.pdf>

OBJECTIVE

To summarize the effects of air pollution (and more specifically of traffic-related air pollution) on the central nervous system

RESULTS

- Elevated air pollution is associated with **decreased cognitive function** in children, adults, and the elderly
- **Olfactory dysfunction, auditory deficits, depressive symptoms**, and other adverse neuropsychological effects have also been reported
- Acute exposure to **300 $\mu\text{g}/\text{m}^3$ diesel exhaust** has been shown to cause **airway inflammation** and to induce EEG (electroencephalogram) changes
- **Perinatal diesel exhaust** exposure was significantly associated with **autism spectrum disorders (ASD)**, particularly in boys
- Newman et al. reported **hyperactivity in 7-year-old children** associated with early life exposure to traffic related air pollution
- Children exposed to high air pollution levels found to have **higher levels of proinflammatory markers** in the cerebrospinal fluid and in serum

CONCLUSIONS

Air pollution is a risk factor for several neuro-related disorders

Study 6:

Residential Proximity to Freeways and Autism in the CHARGE study

(Volk et al., 2011)

Source: Heather E. Volk, Irva Hertz-Picciotto, Lora Delwiche, Fred Lurmann, Rob McConnell,. Residential Proximity to Freeways and Autism in the CHARGE study. Environmental Health Perspectives (2011).

Available from: <https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.1002835>

OBJECTIVE

To associate autism with proximity of residence to freeways during pregnancy and near the time of delivery

METHODOLOGY

Data was collected for 304 autism cases and 259 typically developing controls
Distance of mother's place of residence at the time of birth and also trimester-specific, and freeways were calculated

RESULTS

- Maternal residence at the time of delivery, if **within 309 metres** of a freeway showed association with autism with odds ratio (OR) = 1.86, i.e. **10% children had increased risk of autism** at the time of birth
- Association with autism was seen during each trimester for those living closest to the freeways (<309m), but a **statistically significant** result was obtained for the mothers during their **third trimester**
- No association was found for the maternal residences near other major roads results being same for each trimester

CONCLUSIONS

Maternal residence that were near freeways at the time of delivery showed an association with autism, third trimester being the maximum at risk

Study 7:

Air pollution and daily emergency department visits for depression

(Szyszkowicz M et al., 2009)

OBJECTIVE

To investigate the potential correlation between ambient air pollution exposure and emergency department (ED) visits for depression

METHODOLOGY

A hierarchical clusters design was used to study 27,047 ED visits for depression in six cities in Canada

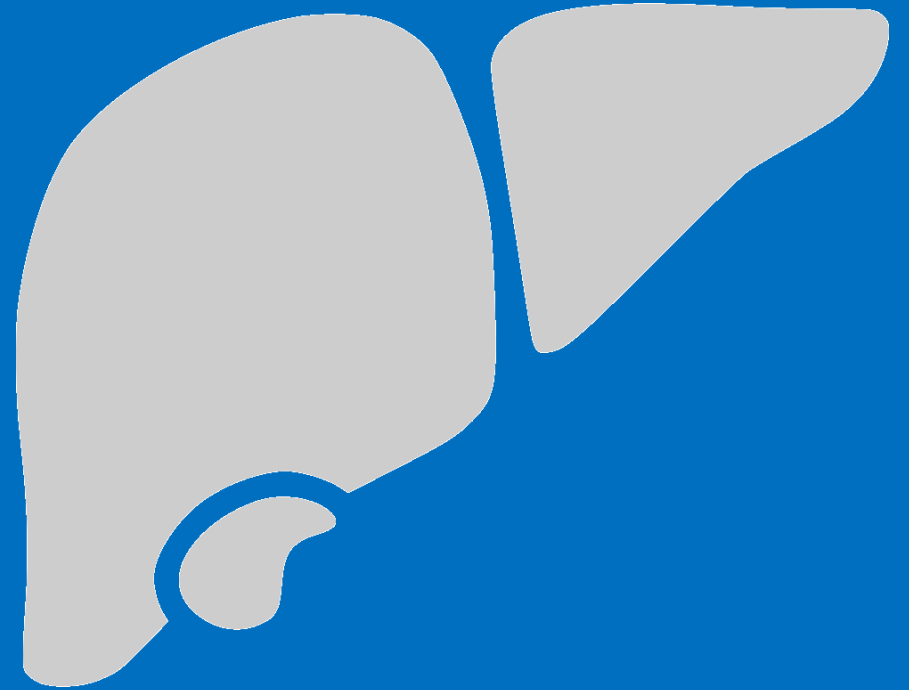
RESULTS

- Statistically significant positive correlations were observed between ED visits for depression and pollutants
 - Per 0.8 ppm of CO, the percentage increase in daily ED visits was **15.5%** (Apr-Sep)
 - Per 20.1 ppb of NO₂, daily ED visits **increased by 20.0%** (Apr-Sep)
 - Per 19.4 ug/m³ of PM10, **largest increase of 7.2%** was seen in colder months (Oct-Mar)

CONCLUSIONS

ED visits for depressive disorder correlate with ambient air pollution

Air Pollution &
Effects on
Liver & Kidney



Air Pollution And Liver

Diseases	Air pollutants	Mechanism of action
Hepatotoxicity	Coal fly ash	Lipid peroxidation, Hepatic megalocytosis, DNA damage
	PM _{2.5} or CB	Generation of ROS, Lipid peroxidation, Genotoxicity, ER stress
	DEP	Genotoxicity, Generation of ROS
NAFLD and Type II diabetes	PM _{2.5} or CB	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
	DEP	Oxidative stress, DNA damage
Liver fibrosis	The total extracts or the PAH fraction of airborne particles	Mitochondrial and Hematogenic damage
Liver cancer	2-NBA, 3-NBA	Genotoxicity, Mutagenic and Carcinogenic activity

Source: Kim JW, Park S, Lim CW, Lee K, Kim B. The Role of Air Pollutants in Initiating Liver Disease. *Toxicol Res.* 2014 Jun;30(2):65–70.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4112066/pdf/toxicr-30-65.pdf>

Study 1:

Particulate matter air pollution and liver cancer survival

(Deng H et al., 2017)

OBJECTIVE

To examine the effect of exposure to ambient PM_{2.5} on hepatocellular carcinoma (HCC) survival

METHODOLOGY

20,221 California Cancer Registry patients with (HCC) diagnosed between 2000 and 2009 were studied for analysis

RESULTS

- PM_{2.5} exposure after diagnosis was statistically significantly associated with HCC survival.
- All-cause mortality hazard ratios (HR) associated with a 1 standard deviation (5.0 µg/m³) 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,
 - **1.05** (95% CI:1.01-1.10) for distant stage

CONCLUSIONS

Exposure to elevated PM_{2.5} after the diagnosis of hepatocellular carcinoma may shorten survival, with larger effects at higher concentrations

Air Pollution and Kidney

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

Study	Method	Subjects	Main result
O'Neill et al. (2008) [15]	Prospective cohort	6,814 Men and women aged 44–84 years who were free of clinical cardiovascular disease at baseline	Chronic and recent PM were not associated with current urinary albumin or microalbuminuria
Lue et al. (2013) [16]	Quantitative study of consecutive patients	Confirmed acute ischemic stroke patients aged ≥ 21 years, residing in the Boston (MA, USA) metropolitan region between 1999 and 2004	Exposure associated with living near a major roadway contributed to reduced renal function (via the estimated glomerular filtration rate)
Mehta et al. (2016) [17]	Prospective cohort	2,280 Male volunteers from the greater Boston area aged 21–80 years	Long-term PM _{2.5} exposure negatively affected renal function and increased renal function decline (via the estimated glomerular filtration rate)

Source: Kim E-A. Particulate Matter (Fine Particle) and Urologic Diseases. *Int Neurourol J.* 2017 Sep 30;21(3):155–62.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5636961/pdf/inj-1734954-477.pdf>

Xu et al. (2016) [18]	Cross-sectional study	Renal biopsy series including 71,151 native biopsies at 938 hospitals spanning 282 cities in China between 2004 and 2014	Long-term exposure to high levels of PM _{2.5} was associated with an increased risk of membranous nephropathy.
Yang et al. (2017) [19]	Cross-sectional population-based study	21,656 Adults evaluated between 2007 and 2009 in New Taipei City who were participating in the Health Screening Program	Exposure during the previous year to PM ₁₀ and PMCoarse, but not PM _{2.5} , was associated with reduced renal function and chronic kidney disease.
Raaschou-Nielsen et al. (2011) [21]	Retrospective cohort study	54,304 Participants in the Danish Diet Cancer and Health cohort	Nitrogen oxides were weakly associated with kidney cancer, without statistical significance.
Raaschou-Nielsen et al. (2017) [20]	Retrospective cohort study	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.	An increased risk of kidney cancer was associated with PM, although not to a statistically significant extent.

Source: Kim E-A. Particulate Matter (Fine Particle) and Urologic Diseases. *Int Neurourol J.* 2017 Sep 30;21(3):155–62.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5636961/pdf/inj-1734954-477.pdf>

Study 2:

Combined toxicity of outdoor air pollution on kidney function
among adult women in Mianyang City, southwest China

(Wang et al., 2020)

Source: Wang, H. H., Zhang, S. C., Wang, J., Chen, X., Yin, H., & Huang, D. Y. (2020). Combined toxicity of outdoor air pollution on kidney function among adult women in Mianyang City, southwest China. *Chemosphere*, 238, 124603.

Available from: <https://www.sciencedirect.com/science/article/pii/S0045653519318272>

METHODOLOGY

Electronic health data of 7071 health adult women (18-65 years old) was collected.

Serum concentrations of uric acid, urea, creatinine, and cystatin C, were measured and individual estimated glomerular filtration rate (eGFR) was calculated.

Monthly average air quality data (including PM_{2.5}, PM₁₀, SO₂, CO, O₃, NO₂ and AQCI) was obtained to calculate the individual average daily dose (ADD)

RESULTS

With IQR 1.25 (1.04 - 1.50m³/day/kg) increase of ADD

Increase was observed in

- **Urea:** 0.218 (0.1888, 0.247) mmol/L mL/min/1.73m²]
- **Uric Acid:** 1.774 (0.318, 3.231) umol/L
- **Creatinine:** 1.501 (1.016, 1.986) umol/L
- **Cystatin C:** 0.006 (0.003, 0.009) mg/L

Note: Seasonal differences in ADD was observed (**highest in winter, lowest in summer**) which corresponded with kidney function

Decrease was observed in

eGFR: -0.776 (-1.106, -0.446)

CONCLUSIONS

First evidence toxicity of combined air pollutants inversely affects kidney function, which might accelerate the risk of CKD

Air Pollution &
Effects on **Skin**



Air Pollution And Skin

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

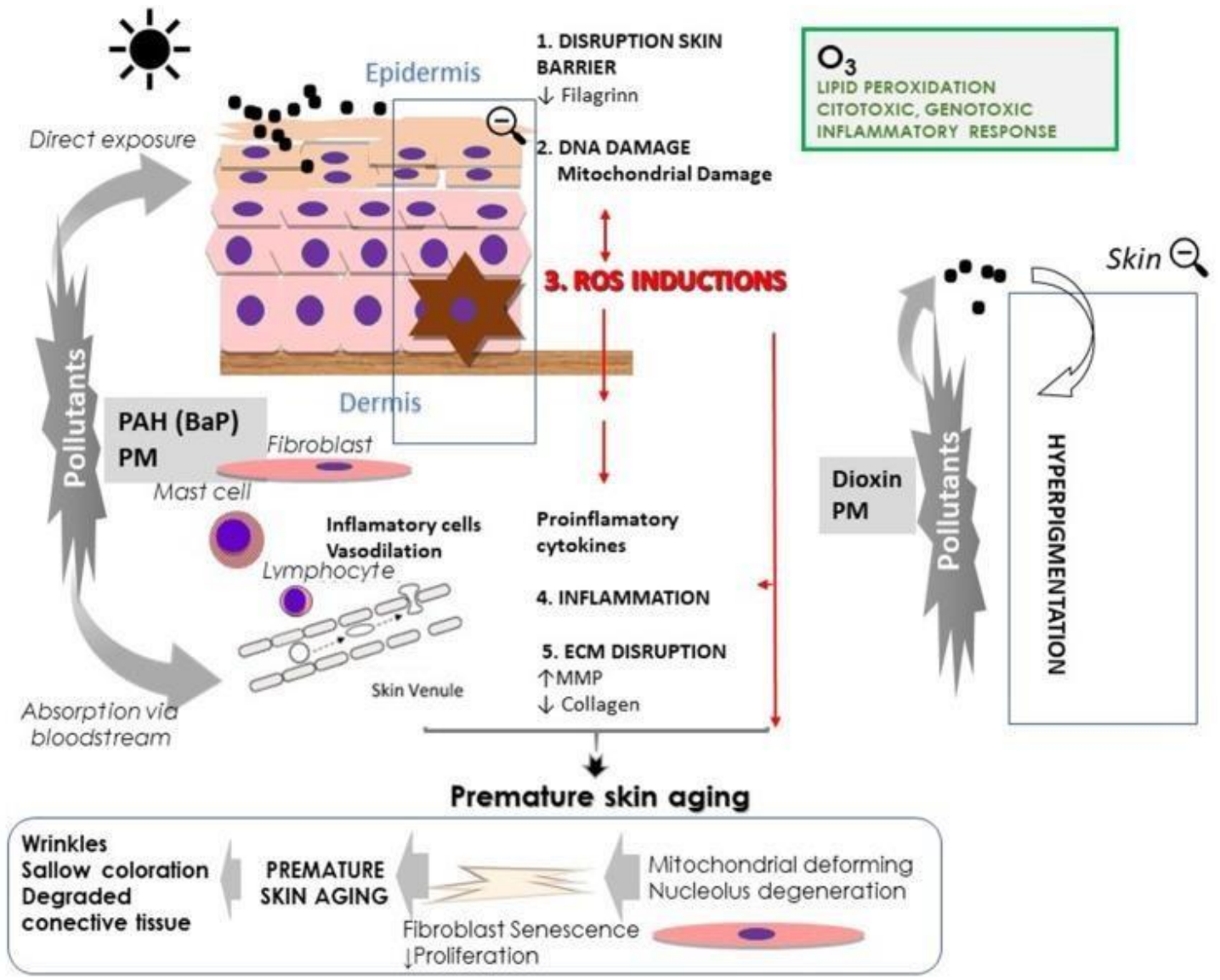


Source: <https://www.theguardian.com/environment/2016/jul/15/air-pollution-causes-wrinkles-and-premature-ageing-new-research-shows>

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.

Skin responses to air pollution (particulate matter, PM; polycyclic aromatic hydrocarbons PAH; and ozone, O₃) and ultraviolet radiation



Study 1:

Symptoms of atopic dermatitis are influenced by outdoor air pollution

(Kim J et al., 2013)

Source: Kim J, Kim E-H, Oh I, Jung K, Han Y, Cheong H-K, et al. Symptoms of atopic dermatitis are influenced by outdoor air pollution. *Journal of Allergy and Clinical Immunology*. 2013 Aug 1;132(2):495-498.e1.

Available from: [https://www.jacionline.org/article/S0091-6749\(13\)00666-0/fulltext](https://www.jacionline.org/article/S0091-6749(13)00666-0/fulltext)

OBJECTIVE

To evaluate the clinical effects of outdoor air pollution on skin symptoms in patients with Atopic dermatitis (AD)

METHODOLOGY

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

Daily mean concentrations of PMs, nitric oxides, volatile organic compounds (VOCs) and 24 hour average temperature and relative humidity from the closest monitoring sites were obtained

RESULTS

- An increased concentration of **PM10** by 1 $\mu\text{g}/\text{m}^3$ was **significantly associated** with a **0.44%** (95% CI, 0.12-0.77) increase in AD symptoms on the following day
- An elevated **benzene** concentration by 1 ppb was associated with a **27.38%** (95% CI, 3.54-56.72) **increase** in AD symptoms
- An increased concentration of **TVOC** by 1 ppb was associated with a **25.86%** (95% CI, 4.01-52.30) increase in AD symptoms on the following day
- This statistical significance disappeared 2 days after the exposure to outdoor air pollutants

CONCLUSIONS

Outdoor air pollution acts as an aggravating factor for AD and may need to be controlled for better management of AD

Study 2:

Acute health effects of urban fine and ultrafine particles on children with atopic dermatitis

(Song S et al., 2011)

OBJECTIVE

To investigate the effects of urban particulate pollutants including ultrafine particles on atopic severity in children with atopic dermatitis (AD)

METHODOLOGY

41 schoolchildren (8-12 years old) who had been diagnosed AD were included

For 67 consecutive days, all of them measured their symptoms in a diary

Daily ambient mass concentrations of PM₁₀, PM_{2.5} and PM₁ and concentrations of submicron particles (0.01- 1 μm) were measured at a local school

RESULTS

- **Significant associations** were found between the concentrations of ultrafine particles and the **itchiness symptom** in children with atopic dermatitis
- An interquartile range (IQR) increase in previous day ultrafine particles concentration (IQR: 28–140/m³) was **significantly associated with a 3.1%** (95% CI, 0.2–6.1) increase in the itch symptom score

CONCLUSIONS

Concentration of ambient ultrafine particles may exacerbate skin symptoms in children with atopic dermatitis

Study 3:

Traffic-Related Air Pollution, Climate, and Prevalence of Eczema in Taiwanese School Children

(Lee Y-L et al., 2008)

Source: Lee Y-L, Su H-J, Sheu H-M, Yu H-S, Guo YL. Traffic-Related Air Pollution, Climate, and Prevalence of Eczema in Taiwanese School Children. *J Invest Dermatol.* 2008 Oct 1;128(10):2412–20.

Available from: [https://www.jidonline.org/article/S0022-202X\(15\)33632-0/pdf](https://www.jidonline.org/article/S0022-202X(15)33632-0/pdf)

OBJECTIVE

To identify the effects of traffic-related air pollutants and climatic factors on eczema prevalence in middle-school students

METHODOLOGY

Nationwide survey of middle-school students in Taiwan from 1995 to 1996 was conducted (n=317,926)
The 12-month prevalence of eczema was compared with air monitoring station data of temperature, relative humidity, and criteria air pollutants

RESULTS

Recurrent Eczema

- Prevalence rates were **2.4 and 2.3%** in boys and girls, respectively
- Recurrent eczema was **associated** with traffic-related air pollution **only in girls**

Flexural Eczema

- Prevalence rates was **1.7%** in both sexes
- Flexural eczema was found to be **significantly associated** with traffic-related air pollutants
 - Boys: RR **1.09**, 95% CI 1.00–1.19
 - Girls: RR **1.12**, 95% CI 1.04–1.22

CONCLUSIONS

Risks of **eczema** were **positively related** to CO and NO_x, but only in girls

Air Pollution &
Linkage with **Diabetes**





Study 1:

Ambient air pollution and diabetes: A systematic review and meta-analysis

(Yang BY et al., 2020)

Source: Yang BY, Fan S, Thiering E, Seissler J, Nowak D, Dong GH, Heinrich J. *Ambient air pollution and diabetes: a systematic review and meta-analysis*. *Environmental Research*. 2020 Jan 1;180:108817.

Available from: <https://www.sciencedirect.com/science/article/pii/S0013935119306140>

OBJECTIVE

To quantify the association between air pollutants and T2D

METHODOLOGY

Out of 716 articles identified, 86 were used for this review and meta-analysis.

RESULTS

- 10/11 population based studies suggested an increase in daily **diabetes-caused mortality** after exposure to days of high **PM** or **black carbon** (BC)
- 6/11 studies reported statistically significant **increased mortality risks**
 - 10- $\mu\text{g}/\text{m}^3$ increment in **PM2.5** was associated with **6–49% increase** in diabetes-related mortality
- 4 cohort studies found that higher levels of **PM2.5** and **NO₂** were associated with greater T2D mortality
- For an increment of 10 $\mu\text{g}/\text{m}^3$ in **PM2.5** and **PM10**, pooled effect for T2D incidence was **1.10** (95% CI 1.04–1.17) and **1.11** (95% CI 1.00–1.22) respectively, based on 11 and 6 studies
- From 25 cross-sectional studies, per 10 $\mu\text{g}/\text{m}^3$ increase of **PM2.5**, **PM10**, and **NO₂**, overall effect estimate was increased by **1.08** (95% CI 1.04–1.12), **1.10** (95% CI 1.03–1.17), and **1.07** (95% CI 1.04–1.11)

CONCLUSIONS

Long-term exposure to air pollution is associated with T2D development and diabetes-related mortality in adults

Study 2:

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

(Yang BY et al., 2018)

Source: Yang BY, Qian Z (Min), Li S, Chen G, Bloom MS, Elliott M, et al. 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. *The Lancet Planetary Health*. 2018 Feb 1;2(2):e64–73.

Available from: <https://www.thelancet.com/action/showPdf?pii=S2542-5196%02818%02930001-9>

OBJECTIVE

To explore the associations of long-term exposure to ambient particulate matter (PM) and gaseous pollutants with diabetes prevalence and glucose-homoeostasis markers

METHODOLOGY

Between April 1 and Dec 31, 2009, 15,477 participants aged 18–74 years were recruited from a large cross-sectional study. Fasting and 2 h insulin and glucose concentrations and the homoeostasis model assessment of insulin resistance index and β -cell function were used as glucose-homoeostasis markers

RESULTS

- Per IQR increase in pollutants, **positive associations with all six pollutants** for diabetes, glucose and insulin homoeostasis markers was observed
- OR for **PM₁**, **PM_{2.5}**, 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
- The associations appeared to be **strongest for PM₁₀ and NO₂**
- Significant associations for all the six pollutants were mainly apparent for the **young age group** (<50 years of age) and for those individuals who were **overweight** or **obese**

CONCLUSIONS

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 3:

Air Pollution as a Risk Factor for Type 2 Diabetes

(Rao X et al., 2015)

OBJECTIVE

To summarize the epidemiologic and experimental evidence between ambient outdoor air pollution and Type 2 Diabetes Mellitus (T2DM)

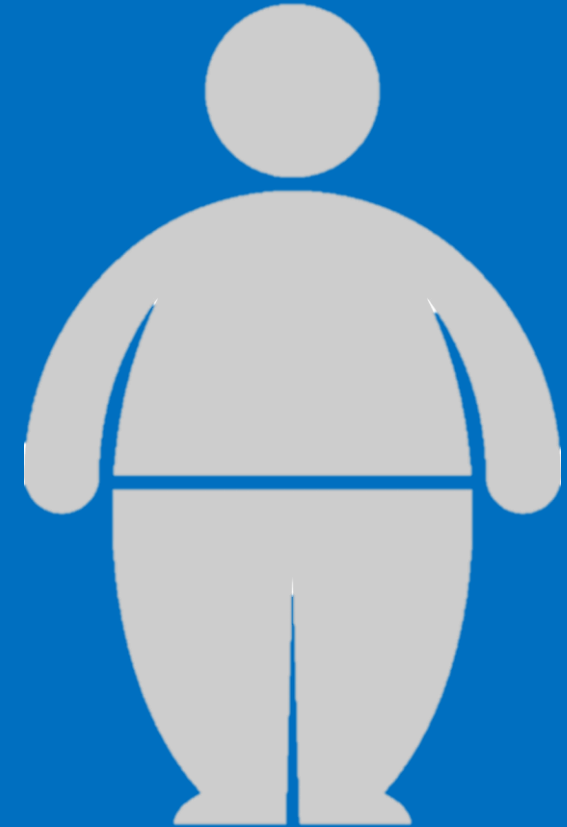
RESULTS

- Kramer et al (2010) found that T2DM incidence **increased by 15%** per IQR traffic-related **PM** or by **15% to 42% per IQR of NO₂** on non diabetic women who were 54–55 years old at baseline
- After an average of 9.7 years of follow-up of 51,818 participants, Andersen et al. detected a positive association between air pollution and confirmed cases of diabetes
 - Hazard ratio (HR) **1.04** (95% CI 1.03–1.08) per IQR of 4.9 mg/m² mean **NO₂** levels
 - The association was **stronger** in people who were **physically active** [HR 1.10 (95% CI 1.03–1.16)] or non-smokers [HR 1.12 (95% CI 1.05–1.20)]
- Pearson et al. found **10,000 additional cases** (**1% increase**) of prevalent diabetes for every 10 mg/m³ increase in PM_{2.5} [2004: $\beta = 0.77$ (95% CI 0.39–1.25), $p < .001$; 2005: $\beta = 0.81$ (0.48–1.07), $p < .001$]

CONCLUSIONS

Air pollution is an important determinant of chronic metabolic disease

Air Pollution &
Effects on
Height & Weight



Study 1:

The association of early-life exposure to ambient PM_{2.5} and later-childhood height-for-age in India: an observational study

(Spears et. al, 2019)

Source: Spears, D., Dey, S., Chowdhury, S., Scovronick, N., Vyas, S., & Apte, J. (2019). The association of early-life exposure to ambient PM_{2.5} and later-childhood height-for-age in India: an observational study. *Environmental Health*, 18(1), 62.

Available from: <https://ehjournal.biomedcentral.com/articles/10.1186/s12940-019-0501-7>

METHODOLOGY

Linked nationally-representative from India's 2015–2016 Demographic and Health Survey (n = 218,152 children under five across 640 districts of India) with satellite-based PM2.5 exposure (concentration) data

RESULTS

1. Children were exposed to an average of **55 $\mu\text{g}/\text{m}^3$** of **PM2.5 in their birth month**
 - The average child is about **0.027 height-for-age SD shorter** than she would be if exposed to very low level of air pollution at birth
 - For an **average 5 year old girl**, this represents a height deficit of **0.13 cm**
2. A **100 $\mu\text{g}/\text{m}^3$ increase in PM2.5** in the month of birth associated with a **0.05 SD reduction** in child height
 - For an average 5 year old girl, this represents a **height deficit of 0.24 [0.05–0.43] cm**
3. Exposure to PM2.5 in the **last trimester in utero** and in the **first few months of life** are significant
4. The most exposed children in India are about **0.06 height-for-age SD shorter** than if they were exposed only at the lowest levels in the sample
 - A district, in this case, would be expected, on average, to have an infant mortality that is larger by 5 infant deaths per 1000 live births

CONCLUSIONS

First study to estimate the association of early-life exposure to ambient PM2.5 on child height-for-age at the range of ambient pollution exposures



Study 2:

Ambient air pollution and overweight and obesity in school-aged children in Barcelona, Spain

(de Bont J et al., 2019)

Source: de Bont J, Casas M, Barrera-Gómez J, Cirach M, Rivas I, Valvi D, et al. Ambient air pollution and overweight and obesity in school-aged children in Barcelona, Spain. *Environ Int.* 2019 Apr;125:58–64.

Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6380992/?report=reader>

OBJECTIVE

To assess whether exposure to ambient air pollution at home and school is associated with overweight and obesity in primary school children

METHODOLOGY

2660 children aged 7-10 years during 2012 in Barcelona were studied for analysis

Child weight and height were measured and age- and sex-specific z-scores for body mass index (zBMI) were calculated

Levels of air pollutants at home and at school were measured and estimated

RESULTS

- An interquartile range increase in **PM10-home** ($5.6 \mu\text{g}/\text{m}^3$) 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 ($>27,346 \text{ particles}/\text{cm}^3$) had a **30% higher odds of being overweight or obese** compared to the lowest tertile of UFP exposure
- Exposure to **NO₂**, **PM2.5** or **Elemental carbon** at schools was **associated with higher odds** of overweight or obese compared to low levels of exposure

CONCLUSIONS

Exposure to ambient air pollution, especially at school, was associated with childhood risk for overweight and obesity

Study 3:

Impact of ambient air pollution on obesity: a systematic review
(An R et al., 2018)

OBJECTIVE

To assess the relationship between air pollution and body weight status

METHODOLOGY

A literature search was conducted for peer-reviewed articles published until September 2017
Out of 6469 articles, 16 studies met the selection criteria and were included in the review.

RESULTS

TOTAL

- Out of 66 associations,
 - Positive: 29 (44%)
 - Negative: 8 (12%)
 - Null: 29 (44%)

CHILDREN

- Out of 25 associations,
 - Positive: 13 (52%)
 - Negative: 5 (20%)
 - Null: 7 (28%)

ADULTS

- Out of 41 associations,
 - Positive: 16 (39%)
 - Negative: 3 (7%)
 - Null: 22 (54%)

POLLUTANTS

- 47% (8/17) found positive association with **PM**
- 55% (6/11) found positive association with **NO₂**
- 70% (7/10) found a positive association with **O₃**
- 40% (4/10) found positive association with **SO₂**

CONCLUSIONS

Concurrent evidence regarding the impact of air pollution on body weight status remains mixed

Study 4:

Traffic-related air pollution and obesity formation in children:
a longitudinal, multilevel analysis

(Jerrett M et al., 2014)

Source: Jerrett M, McConnell R, Wolch J, Chang R, Lam C, Dunton G, et al. Traffic-related air pollution and obesity formation in children: a longitudinal, multilevel analysis. Environ Health. 2014 Dec;13(1):49.

Available from: <https://ehjournal.biomedcentral.com/track/pdf/10.1186/1476-069X-13-49>

OBJECTIVE

To determine whether traffic density and traffic-related air pollution were positively associated with growth in BMI in children

METHODOLOGY

Participants were drawn from a prospective cohort of children 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.

RESULTS

- Traffic pollution was **positively associated** with growth in BMI and was robust to adjustment for many confounders
- A **13.6% increase** in annual BMI growth when comparing the lowest to the highest tenth percentile of air pollution exposure
- This increase resulted in an increase of nearly **0.4 BMI units** on attained BMI at age 10

CONCLUSIONS

Traffic-related air pollution exerted a significant effect on BMI growth

Standard Level of Air Pollutants

Air Pollutants	Major Source Of Emission	Averaging Time	Standard Level	Health Impact Target Organs
Particle pollutants				
PM _{2.5}	Motor engines, industrial activities, smokes	24 h	35 µg/m ³	Respiratory and cardiovascular diseases,
PM ₁₀		24 h	150 µg/m ³	CNS and reproductive dysfunctions, cancer
Ground-level ozone	Vehicular exhaust, industrial activities	1 h	0.12 mg/m ³	Respiratory and cardiovascular dysfunctions, eye irritation
Carbon monoxide	Motor engines, burning coal, oil and wood, industrial activities, smokes	1 h	35 mg/m ³	CNS and cardiovascular damages
Sulfur dioxide	Fuel combustion, burning coal	1 h	75 µg/m ³	Respiratory and CNS involvement, eye irritation
Nitrogen dioxide	Fuel-burning, vehicular exhaust	1 h	100 µg/m ³	Damage to liver, lung, spleen, and blood
Lead	Lead smelting, industrial activities, leaded petrol	3 months average	0.15 µg/m ³	CNS and hematologic dysfunctions, eye irritation
Polycyclic aromatic hydrocarbons*	Fuel combustion, wood fires, motor engines	1 year	1 ng/m ³	Respiratory and CNS involvement, cancer

*Air quality standards according to the European Union; *PM_{2.5} is stand for PM of 2.5 µ or less. PM₁₀ is stand for PM of 10 µ or more. PM = Particulate matter, CNS = Central nervous system

NETWORK OF

PASSIONATE & INFORMED DOCTORS

LEADING THE FIGHT
AGAINST AIR POLLUTION



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LUNG CARE
FOUNDATION

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.



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.





Clean Air Is A Human Right!
If We Don't Act Today,
Millions Die

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