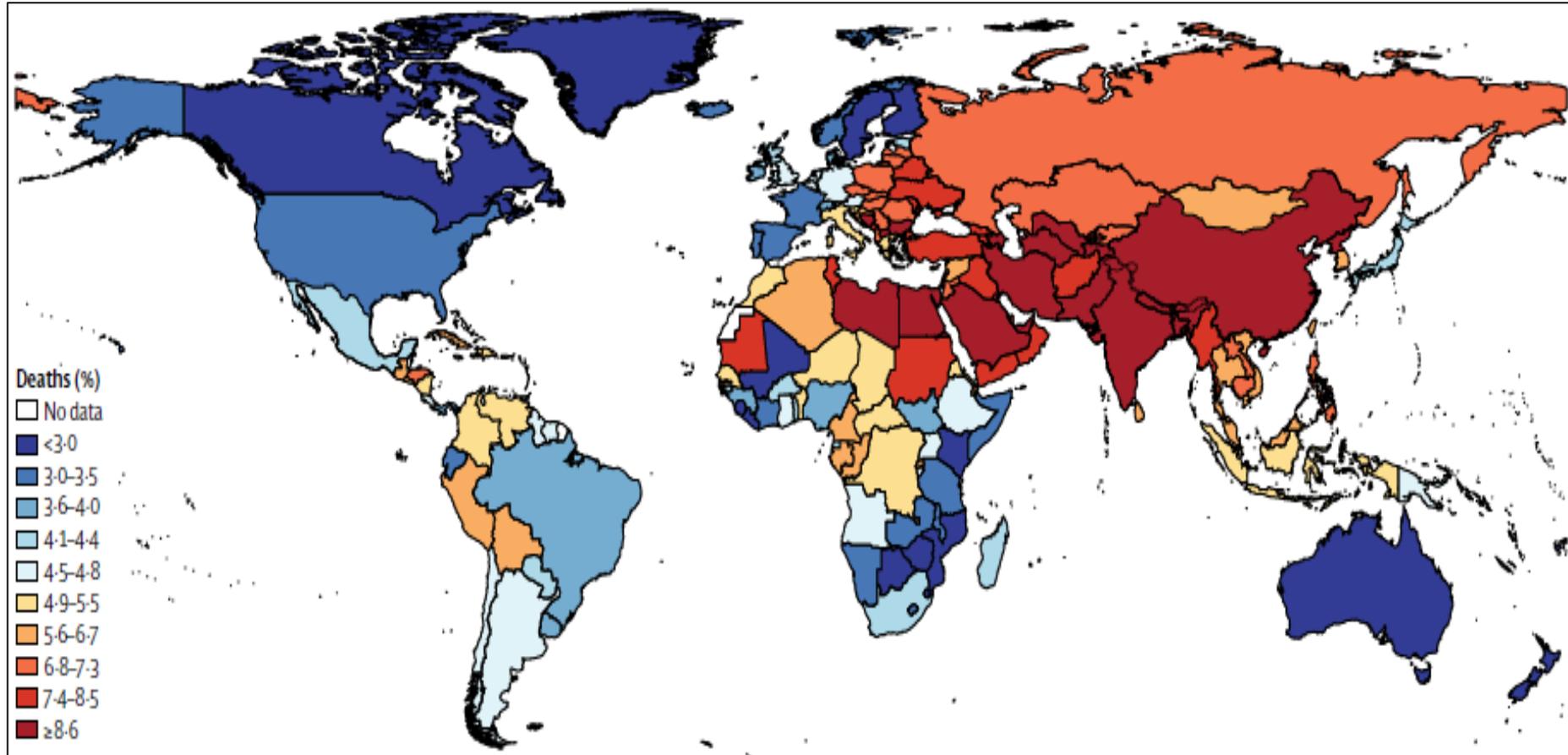


Deaths attributable to ambient particulate matter pollution in 2015



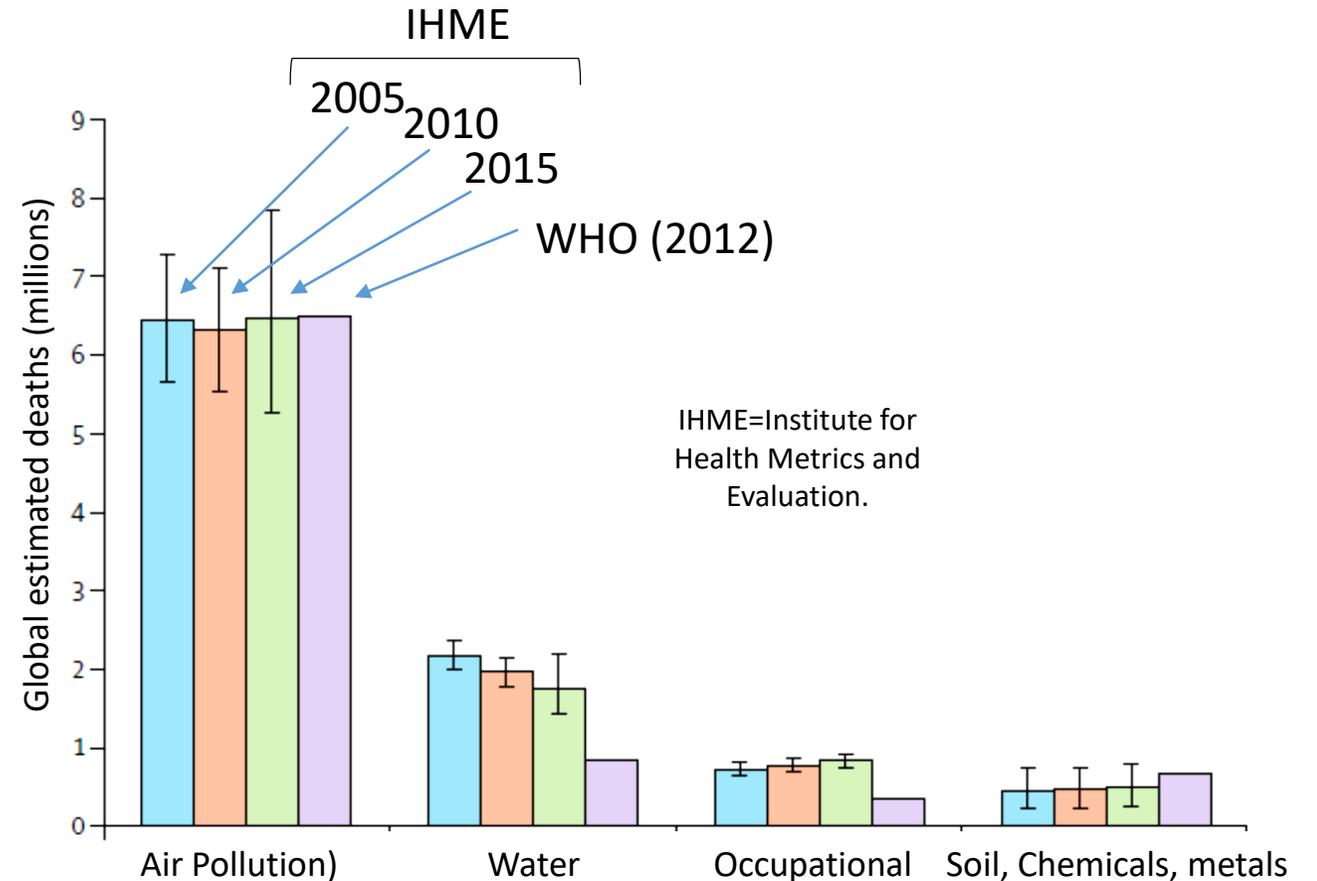
Global estimated deaths (millions) by pollution risk factor, 2005-15

Using data from the GBD study (2015) and WHO data (2012)

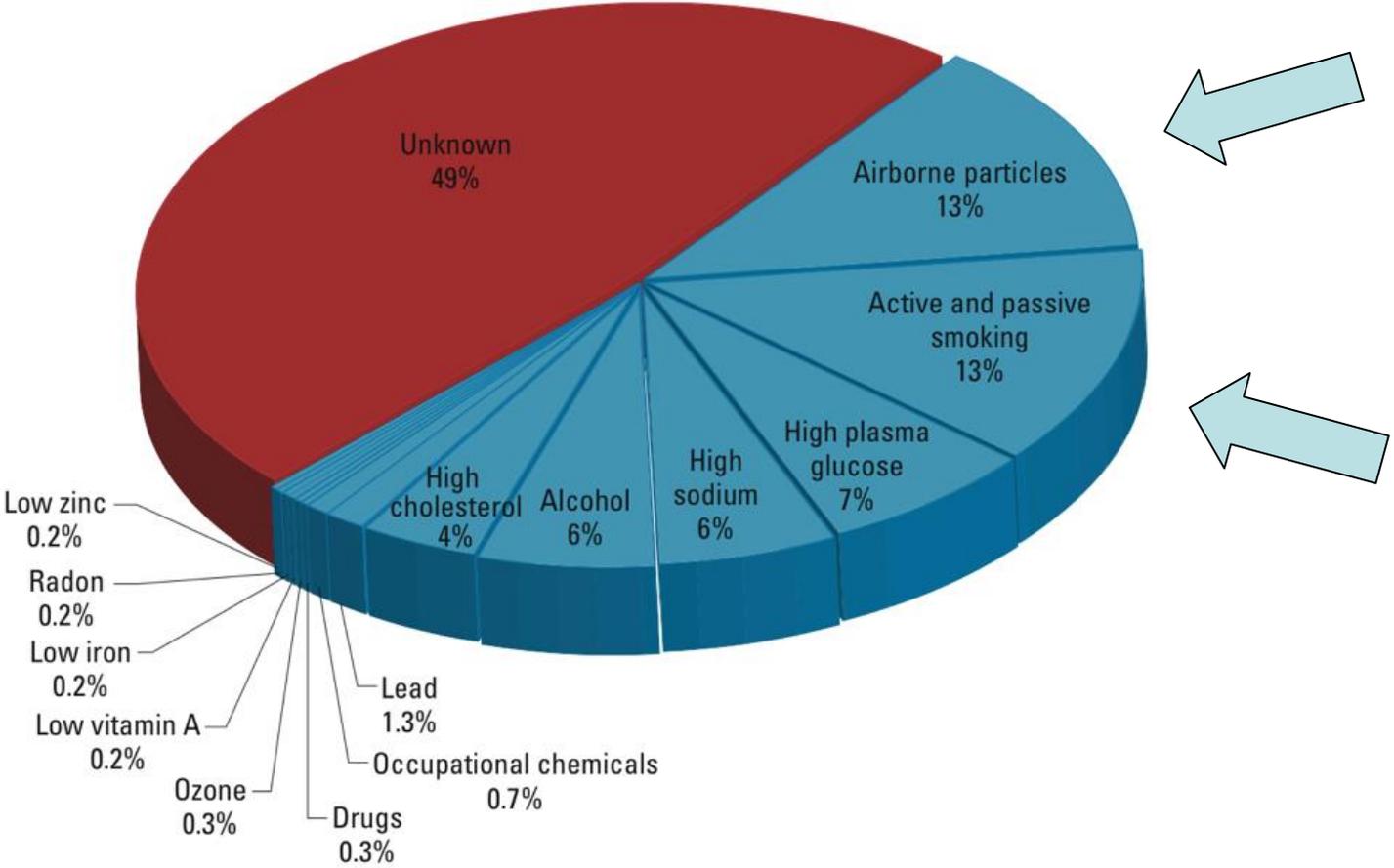
The Lancet Commission on pollution and health. Landrigan PJ et al. Published Online October 19, 2017; [http://dx.doi.org/10.1016/S0140-6736\(17\)32345-0](http://dx.doi.org/10.1016/S0140-6736(17)32345-0)

	GBD study best estimate (95% CI)	WHO best estimate (95% CI)
Air (total)	6.5 (5.7-7.3)	6.5 (5.4-7.4)
Household air	2.9 (2.2-3.6)	4.3 (3.7-4.8)
Ambient particulate	4.2 (3.7-4.8)	3.0 (3.7-4.8)
Ambient ozone	0.3 (0.1-0.4)	..
Water (total)	1.8 (1.4-2.2)	0.8 (0.7-1.0)
Unsafe sanitation	0.8 (0.7-0.9)	0.3 (0.1-0.4)
Unsafe source	1.3 (1.0-1.4)	0.5 (0.2-0.7)
Occupational	0.8 (0.8-0.9)	0.4 (0.3-0.4)
Carcinogens	0.5 (0.5-0.5)	0.1 (0.1-0.1)
Particulates	0.4 (0.3-0.4)	0.2 (0.2-0.3)
Soil, heavy metals, and chemicals	0.5 (0.2-0.8)	0.7 (0.2-0.8)
Lead	0.5 (0.2-0.8)	0.7 (0.2-0.8)
Total	9.0	8.4

Note that the totals for air pollution, water pollution, and all pollution are less than the arithmetic sum of the individual risk factors within each of these categories because these have overlapping contributions—eg, household air pollution also contributes to ambient air pollution and vice versa.



Risk factors for exposures that contribute to chronic-disease mortality. The chart was compiled from World Health Organization estimates of **exposures affecting 50 million global deaths in 2010**



Air pollution is now the world's largest single environmental health risk and that reducing air pollution could save millions of lives.

Outdoor air pollution-caused deaths

Source: World Health Organization figures, 2012

- 1) 40% – coronary heart disease
- 2) 40% – stroke
- 3) 11% – lung diseases like bronchitis (COPD)
- 4) 6% - lung cancer
- 5) 3% – respiratory infections in children



Indoor air pollution-caused deaths

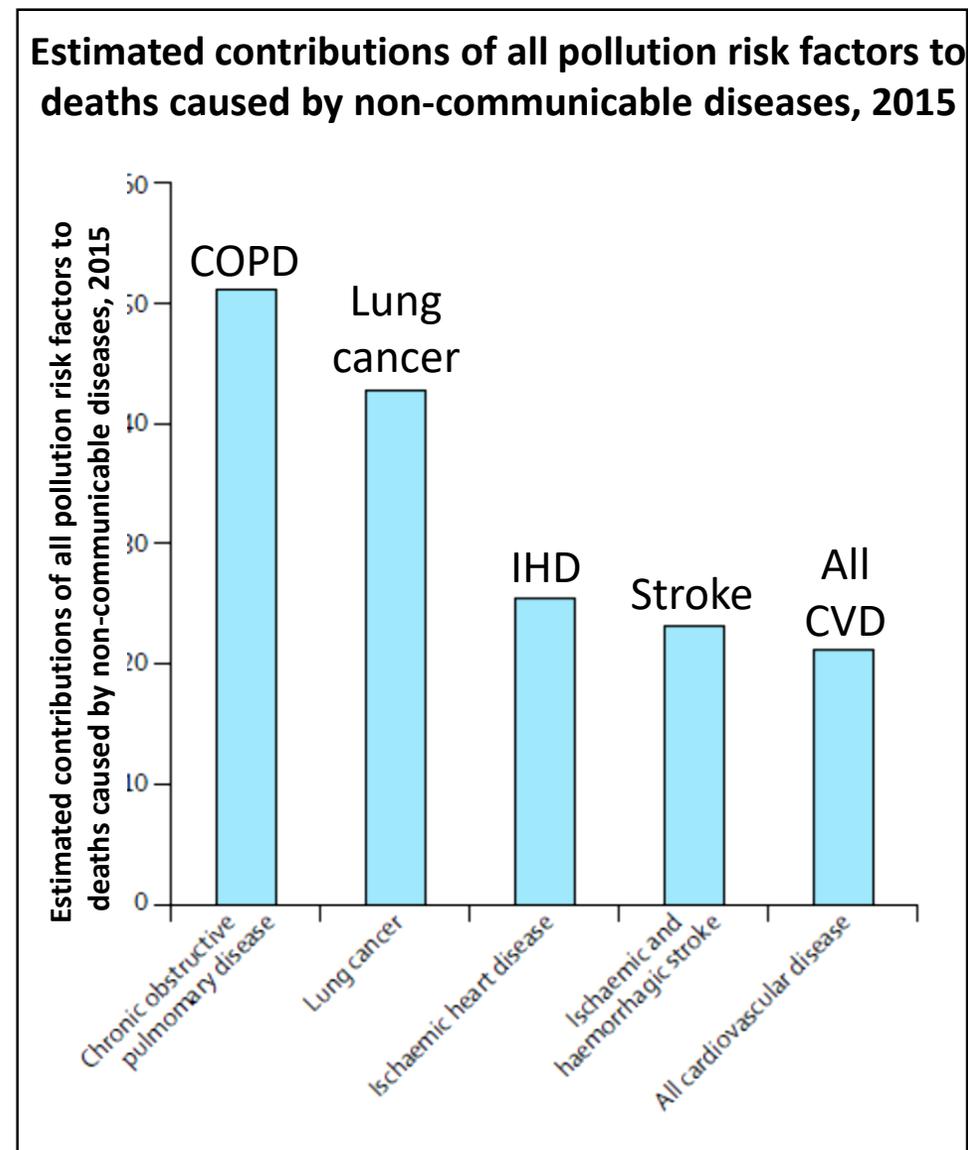
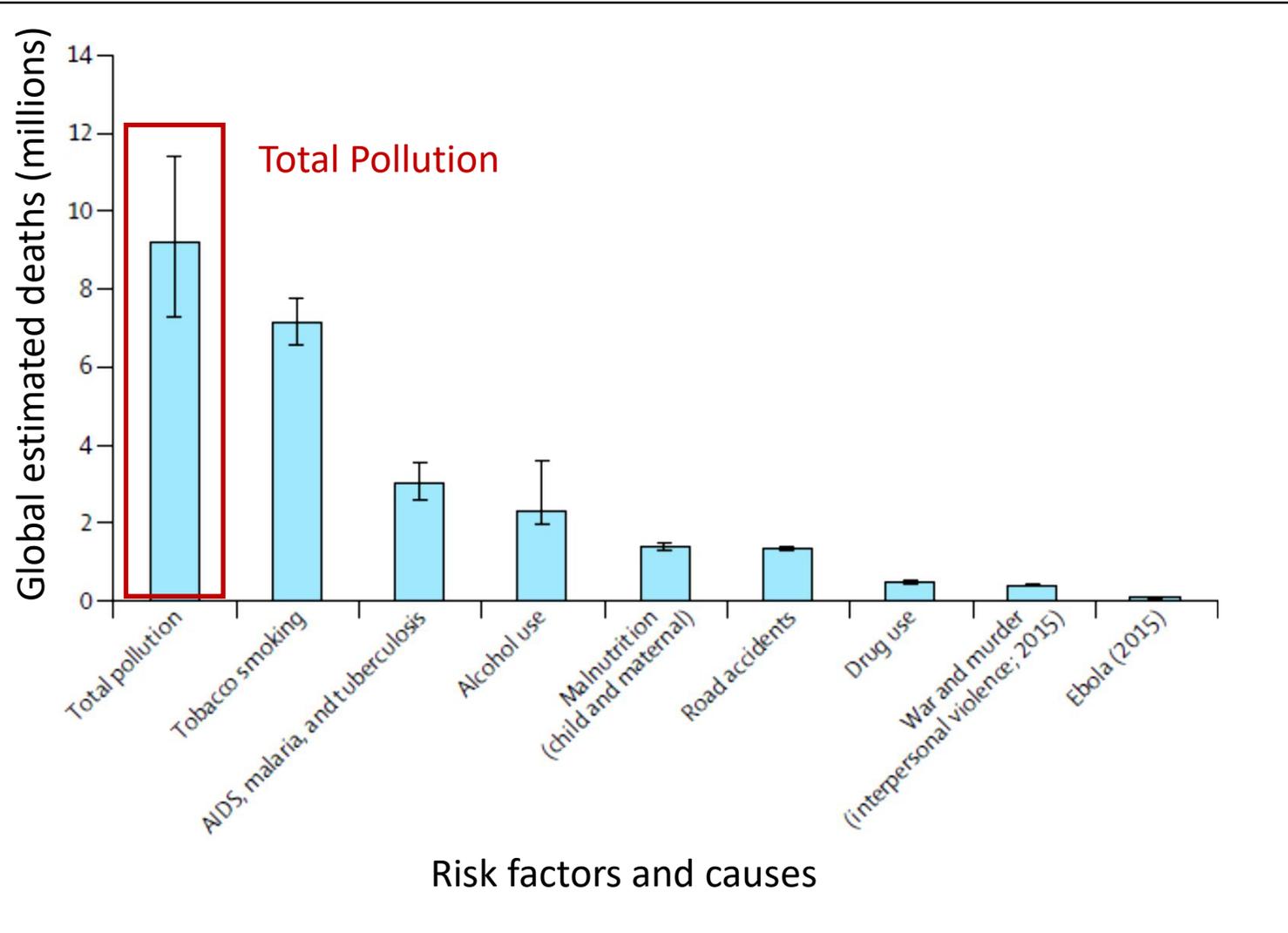
Source: World Health Organization figures, 2012

- 1) 34% - stroke
- 2) 26% - coronary heart disease
- 3) 22% - COPD
- 4) 12% - respiratory infections in children
- 5) 6% - lung cancer



Global estimated deaths by major risk factor and cause, 2015

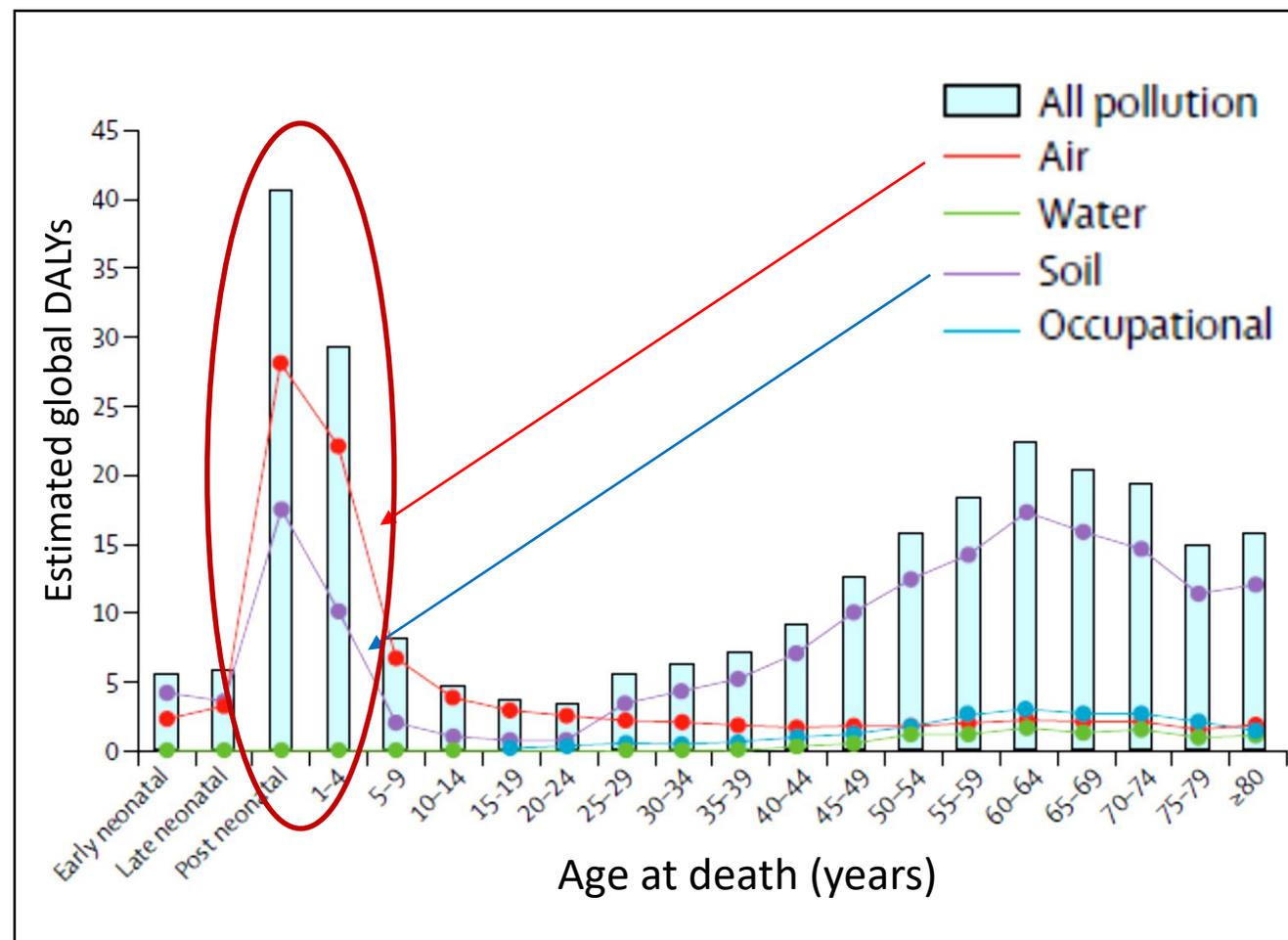
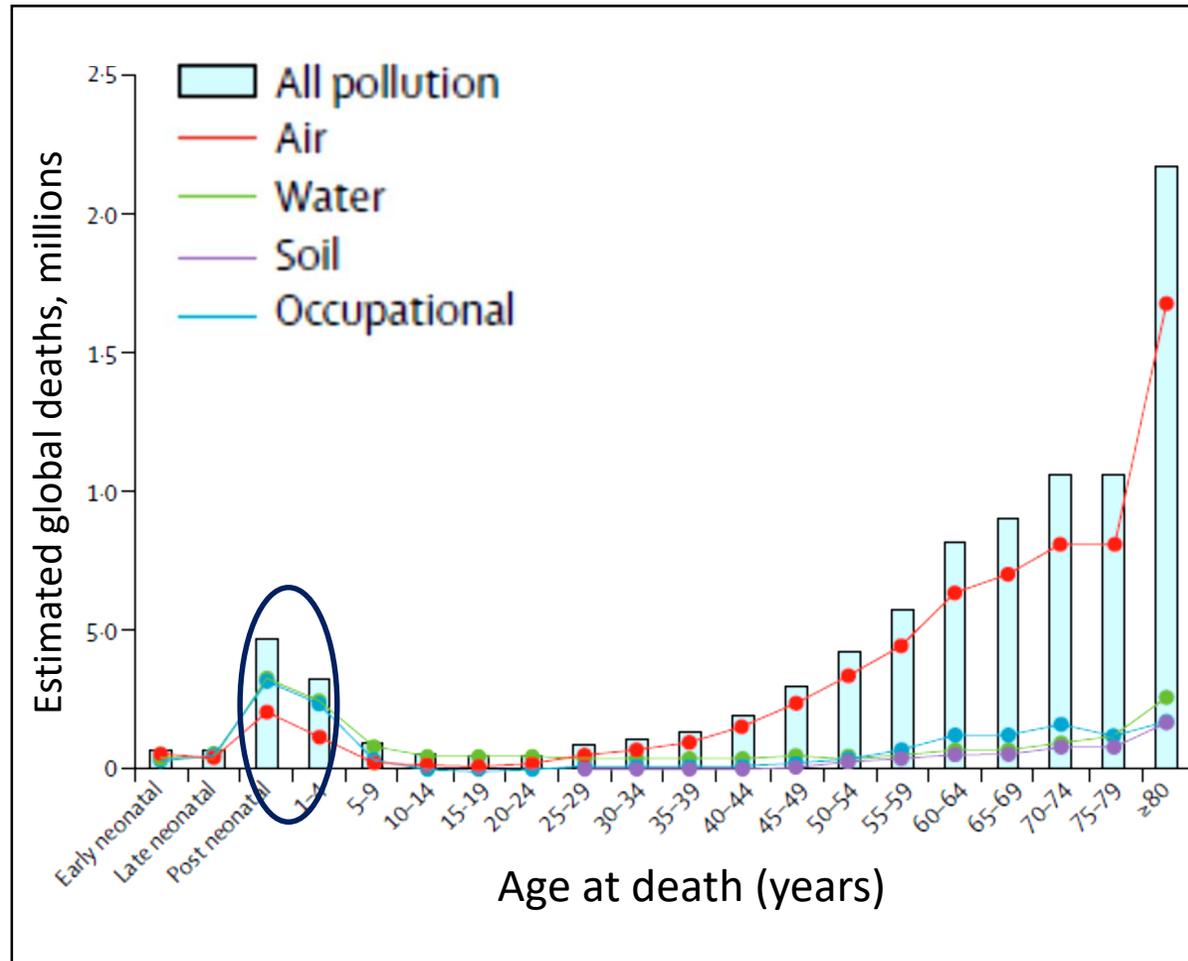
Using data from the GBD Study, 2016.



Estimated global deaths (left) and global Disability Adjusted Life Years (DALYs, right) by pollution risk factor and age at death by pollution risk factor, 2015

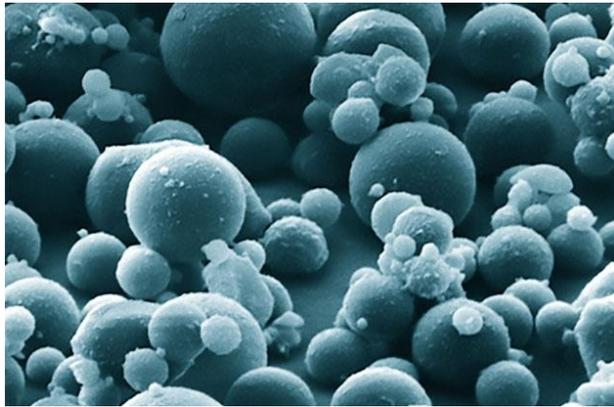
WHO GBD Study, 2016.

The *Lancet* Commission on pollution and health

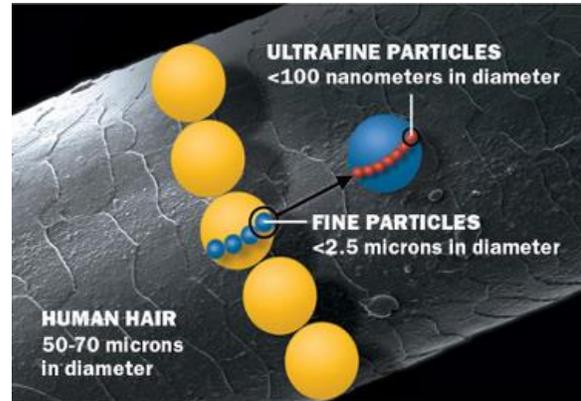


Types of outdoor air pollution: NO₂, Ozone (O₃), SO₂, Particles and PAHs

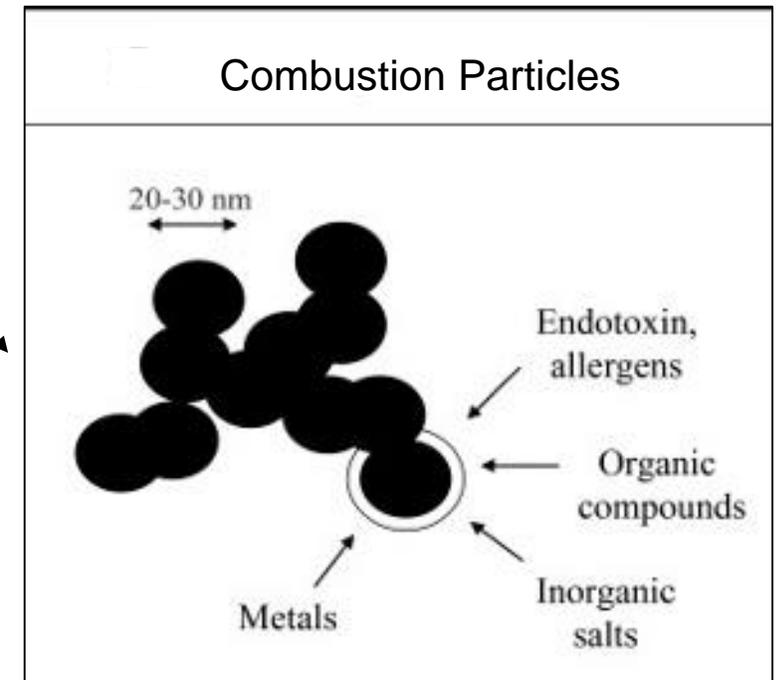
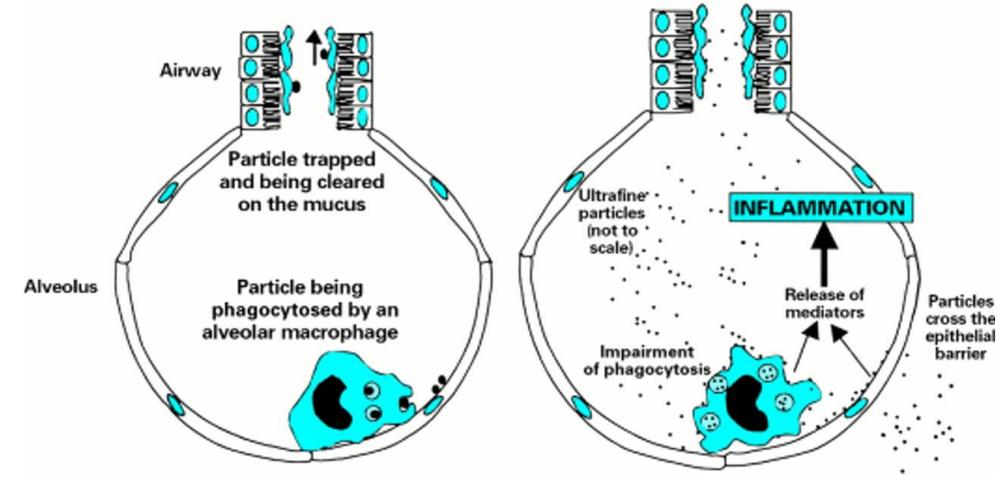
Particulates



Particle air pollution remains the greatest concern: PM₁₀, PM_{2.5} and PM_{0.1}



The most damaging component of air pollution are the particles – described by size, but what are the chemicals involved?



RCP/RCPH Working Party on Air Pollution

Every breath we take: the lifelong
impact of air pollution
Feb 23rd 2016

Professor Stephen Holgate
Chair RCP WP on Air Pollution, MRC
Professor University of Southampton.

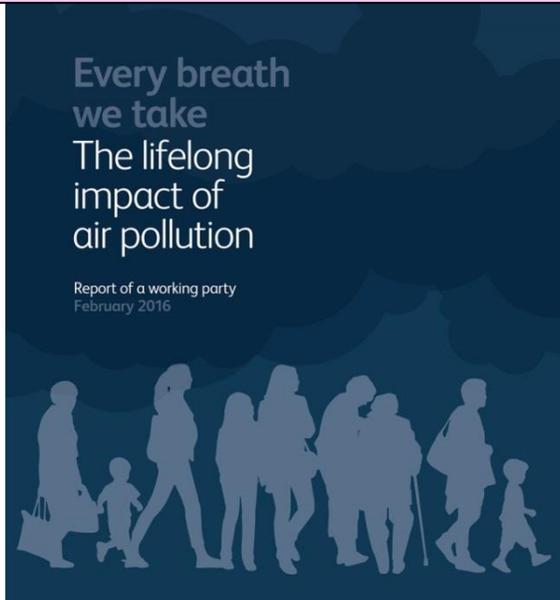


Royal College
of Physicians

Setting higher standards

Since February 2016, considerable progress is being made

Ministerial Round Table March 2018 to take stock and move forward



- Estimated cost of air pollution is £20bn annually in the UK
- Linked to major health challenges of our day such as heart disease, asthma, COPD, lung cancer, diabetes and dementia

February 5th 2017 - Ribble_Cycles surveyed more than 1,060 adults in Britain.

The average person spent 92% of their time indoors on a weekly basis.

The average person in Britain spends just 8 per cent of their time outside on a week day, meaning less than two hours a day out of doors.

Most of this time is spent walking to the shops or the car, but men are slightly better at getting out than women, at 28 minutes more per week day.

Brits also admit to spending 1 hour 37 minutes per day less outside during winter in comparison to summer.

- Taking pets for a walk (17%)
- Walking to the shop at lunchtime (16%)
- Walking to and from the car (15%)
- Walking to work from my bus/train (14%)
- Going for a run (6%)
- Walking the kids to school (5%)
- Smoking (4%)
- Cycling to work (2%)

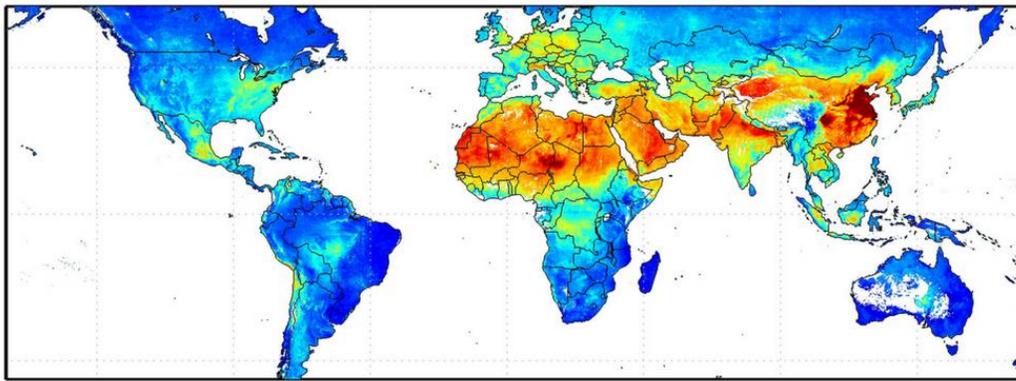


Indoor air pollution in Asia

China is one of the world's fastest growing economies—with no environmental regulation

India has some 500,000 annual deaths from indoor air pollution

Bangladesh has about 100,000 annual deaths from indoor air pollution



Satellite-Derived PM_{2.5} [$\mu\text{g}/\text{m}^3$]

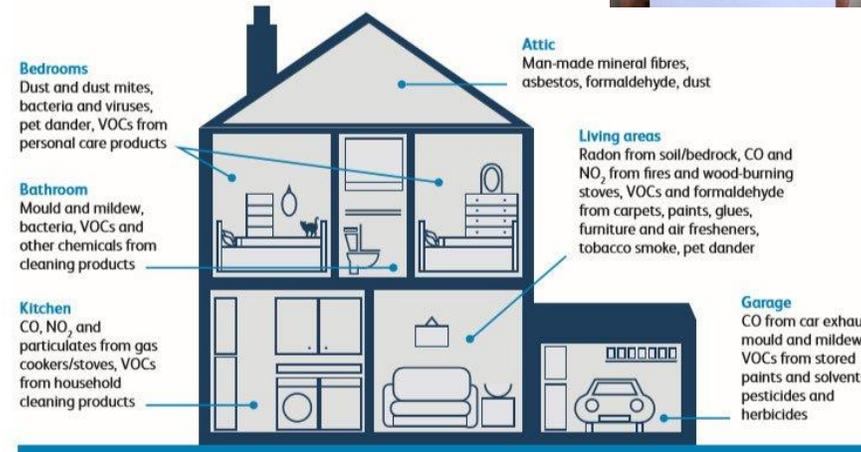
Global satellite-derived map of PM_{2.5} averaged over 2001-2006.

Health Effects of Indoor Air Pollution

- Nearly 3 billion people in the world use solid fuels for cooking
- One of the most dangerous emissions from these fuels is PM_{2.5} (**particulate matter 2.5**)
- PM_{2.5} are very small particles that get deep into your lungs when you breathe
- These particles, along with other emissions, can cause serious health conditions
- Scientists and engineers are investigating to find better ways for people without much money to cook their meals and heat their homes



- ❖ Level of particulates in home using biofuel: **>1000** $\mu\text{g}/\text{m}^3$ (24 hr mean)
- ❖ Can reach **10 000** $\mu\text{g}/\text{m}^3$ PM₁₀ (if using an open fire)
- ❖ EPA: **50** $\mu\text{g}/\text{m}^3$ PM₁₀ annual mean
- ❖ Women and young children have greatest exposure

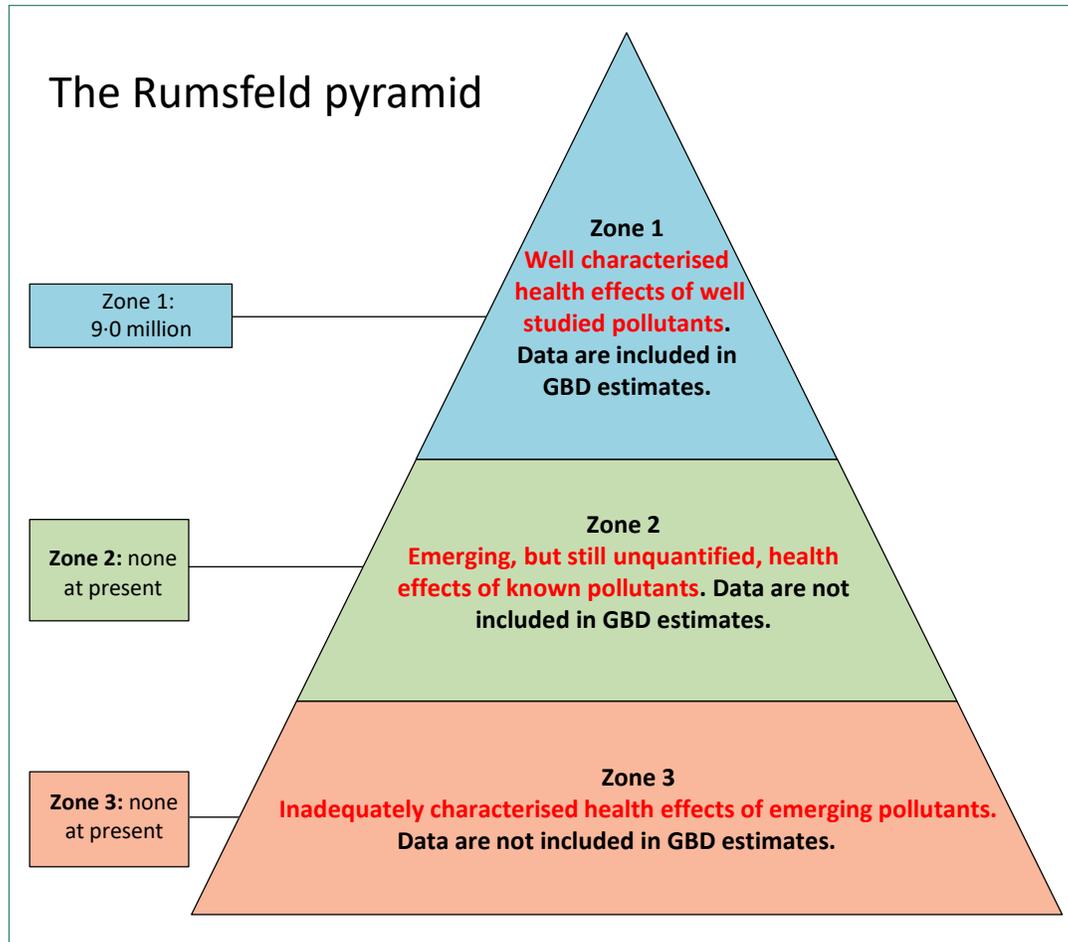


11. Quantify the relationship between indoor air pollution and health. We must strengthen our understanding of the relationship between indoor air pollution and health, including the key risk factors and effects of poor air quality in our homes, schools and workplaces. A coordinated effort among policymaking bodies will be required to develop and apply any necessary policy changes

“The Pollutome”

Numbers of pollution-related deaths included in GBD estimates by zone

The Lancet Commission on pollution and health. Landrigan PJ et al. Published Online October 19, 2017; [http://dx.doi.org/10.1016/S0140-6736\(17\)32345-0](http://dx.doi.org/10.1016/S0140-6736(17)32345-0)

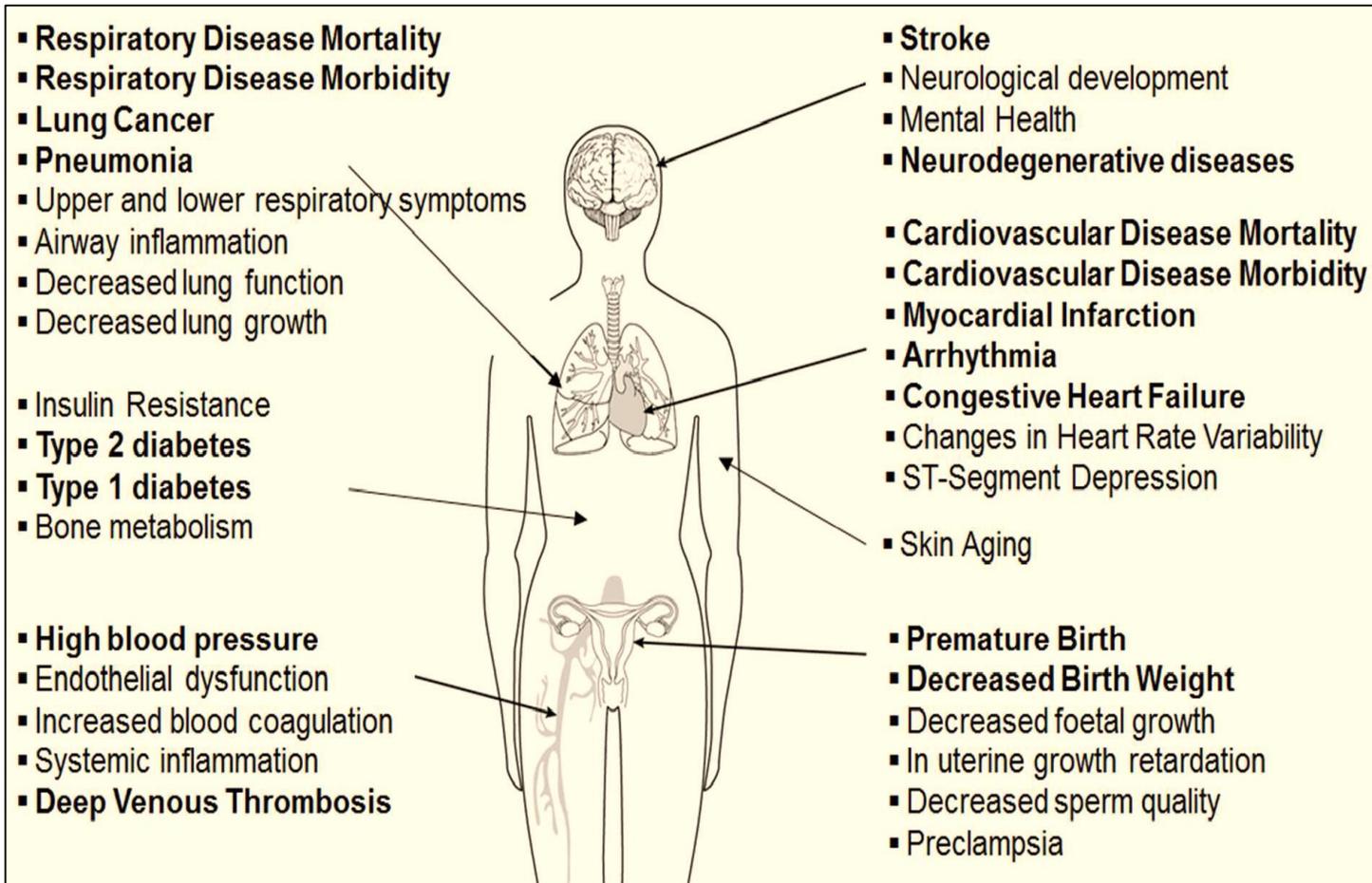


<p>Selenium Exposure to high concentrations causes Selenosis, which can cause hair-loss, nail brittleness, and neurological abnormalities (e.g. numbness and other odd sensations in the extremities).¹¹</p>	<p>Lead Lead exposure can cause brain damage, nervous system damage, blood disorders, kidney damage, and damage to fetal development. Children are especially vulnerable.</p>
<p>Beryllium Exposure can cause lung cancer and chronic Beryllium disease. Symptoms of chronic beryllium disease include: breathing difficulties, coughing, chest pain, and general weakness.</p>	<p>Polyvinyl chloride (PVC) PVC is the most used plastic, found in everyday electronics. When burned it produces large quantities of hydrogen chloride gas, which combines with water to form hydrochloric acid (HCl). Inhaling HCl can cause respiratory problems. Production and incineration of PVC creates dioxins.¹¹</p>
<p>Mercury Exposure through ingestion or inhalation can cause central nervous system damage and kidney damage.¹</p>	<p>Barium Exposure may lead to brain swelling, muscle weakness, damage to heart, liver and spleen, or increased blood pressure.¹</p>
<p>Chromium (IV) - Hexavalent Chromium Exposure can cause strong allergic reaction (linked to Asthmatic Bronchitis) and DNA damage to cells. Workers are exposed at disposal stage and Chromium (IV) can also be released into the environment from landfills and incineration.¹</p>	<p>Brominated flame retardants (BFRs) Suspected of hormonal interference (damage to growth and sexual development), and reproductive harm, BFRs are used to make materials more flame resistant. Exposure studies reveal BFRs in breast milk and blood of electronics workers, among others.¹</p>
<p>Arsenic Long-term exposure may cause lung cancer, nerve damage and various skin diseases. Arsine gas (AsH₃), used in tech manufacturing, is the most toxic form of arsenic.¹</p>	<p>Polychlorinated biphenyls (PCBs) Toxic effects of PCBs include immune suppression, liver damage, cancer promotion, nervous damage, reproductive damage (both male and female), and behavioral changes. PCBs were widely used (prior to 1980) in transformers and capacitors. Though banned in many countries, they are still present in e-waste.¹²</p>
<p>Trichloroethylene (TCE) Exposure to TCE (depending on amount and route) can cause liver and kidney damage, impaired immune system function, impaired fetal development, or death. Manufacturing workers and communities where TCE leaches into drinking water are at greatest risk.¹³</p>	<p>Dioxins and Furans skin disorders; liver problems; impairment of the immune system, the endocrine system and reproductive functions; effects on the developing nervous system and some types of cancers.</p>
<p>Cadmium Long-term exposure to cadmium can cause kidney damage and damage to bone density. Cadmium is also a known carcinogen.</p>	

Overview of diseases, conditions, and biomarkers affected by outdoor air pollution.

Conditions currently included in the Global Burden of Disease categories are shown in bold

An ERS & ATS Policy Statement: Aug 2016: What Constitutes an Adverse Health Effect of Air Pollution? An analytical framework



Health effects of pollutants across 24 hours/day of exposures

Morning

Traffic pollution
Particulates, nitrogen dioxide, ozone

Day

School buildings and activities
Radon, mould spores, VOCs, carbon dioxide

Kitchen products and cooking appliances
Particulates, PAHs, carbon monoxide, nitrogen dioxide, VOCs

Evening/night

Flowers
Pollen, mould spores from soil

Open fire
Carbon monoxide and nitrogen dioxide

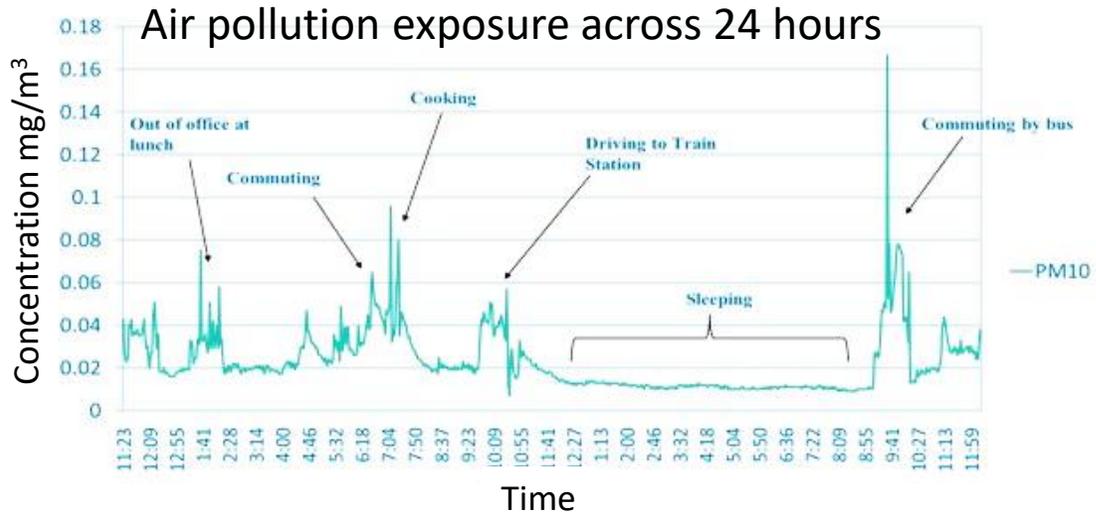
Cigarette smoke
Hundreds of hazardous compounds

Personal care products
VOCs

Cat
Dander

Carpets and sofa cushions
House-dust mites, VOCs

Vapours from chipboard furniture
Formaldehyde



Formaldehyde C=O CH2O CH2O

How Dangerous are Flame Retardants?

Common Indoor Air Problems



Moisture



VOCs and Chemicals



Smoking



Dust



Pet Dander



A person's home is his/her castle



Environmental chemical influences on health

- Chemical burden on the developing foetus e.g. asthma/allergies, cognition, lung and cardiovascular development
- Environmental chemicals as drivers of somatic mutations and endocrine pathways in cancers
- Decline in male and female fertility
- Pollutant drivers for chronic inflammatory diseases e.g. asthma, IBD, RA, mental health
- The role of chemical exposure in aging diseases e.g. COPD, dementia, type 2 diabetes, metabolic syndrome Parkinson's

OUTDOORS

INDOORS

Outdoor-source
Air pollutants
Primary pollutants
Secondary pollutants

Loss due to filtration

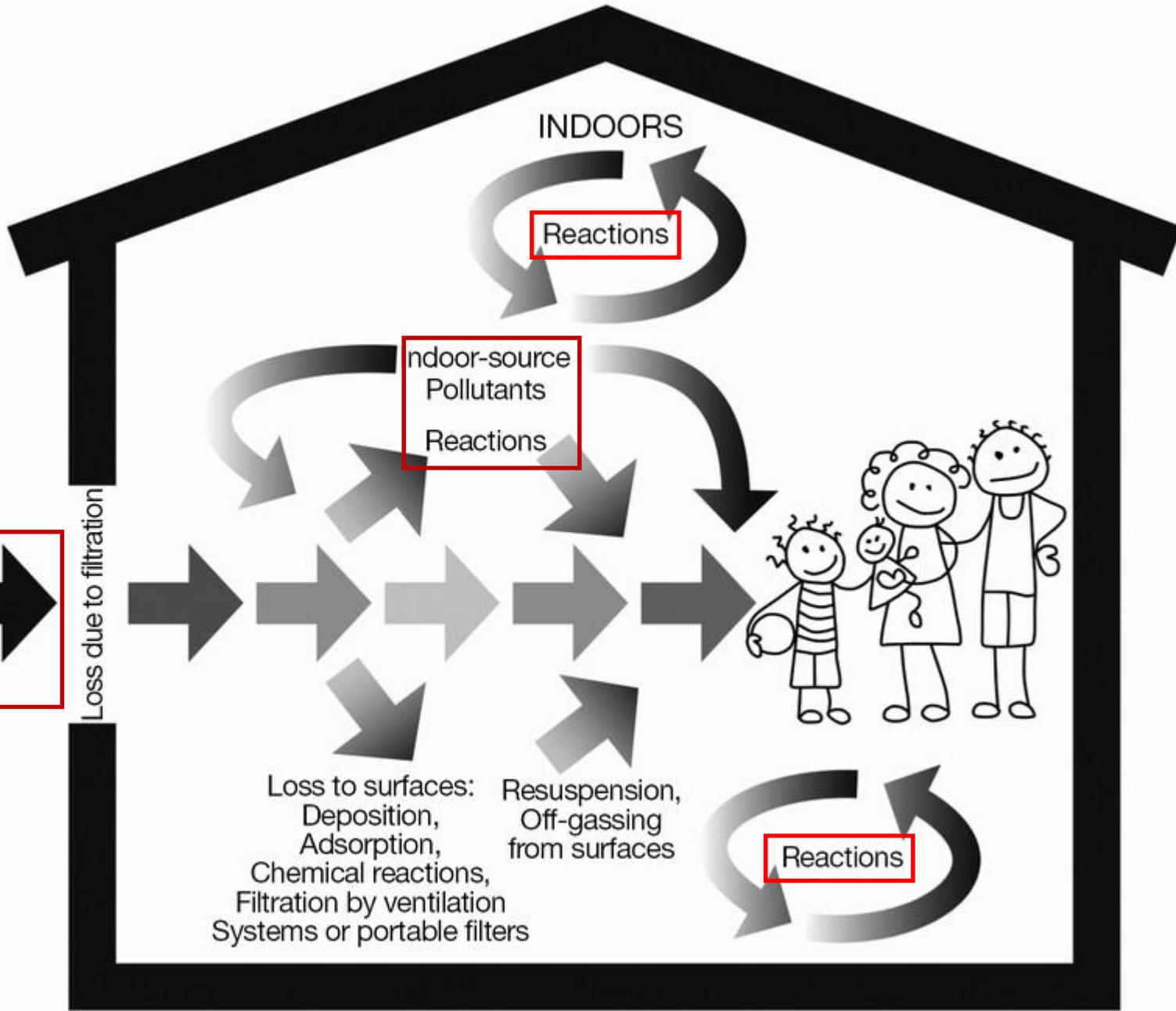
Indoor-source
Pollutants
Reactions

Loss to surfaces:
Deposition,
Adsorption,
Chemical reactions,
Filtration by ventilation
Systems or portable filters

Resuspension,
Off-gassing
from surfaces

Reactions

Reactions

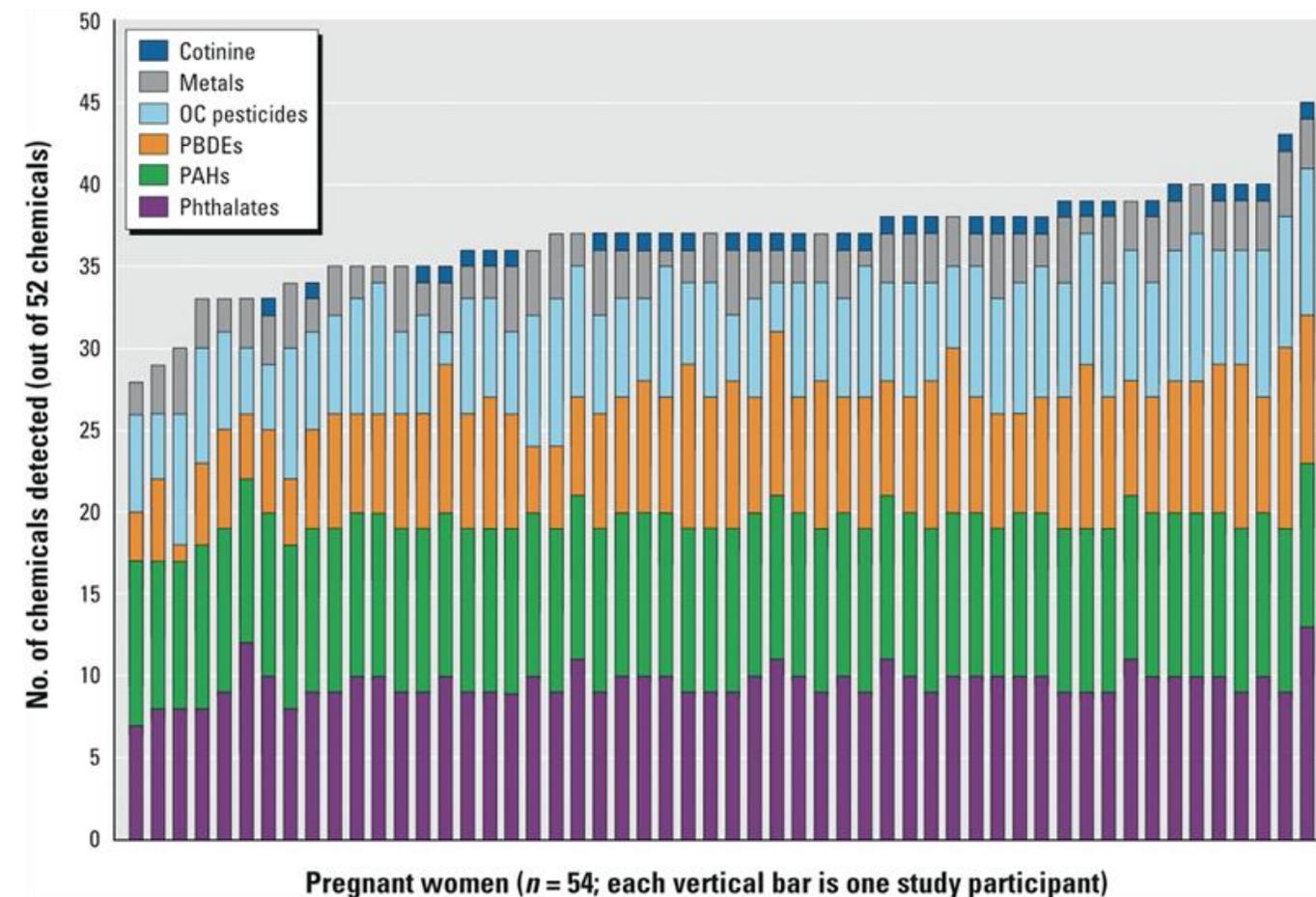


Environmental Chemicals in Pregnant Women in the United States: NHANES 2003–2004

Woodruff, TJ et al. Environ Health Perspect. 2011; 119: 878–85

Number of chemicals detected by chemical class in U.S. pregnant women, NHANES subsample B [metals, cotinine, organochlorine (OC) pesticides, phthalates, brominated flame retardants (PBDEs), and PAHs], 2003-2004 (n=54).

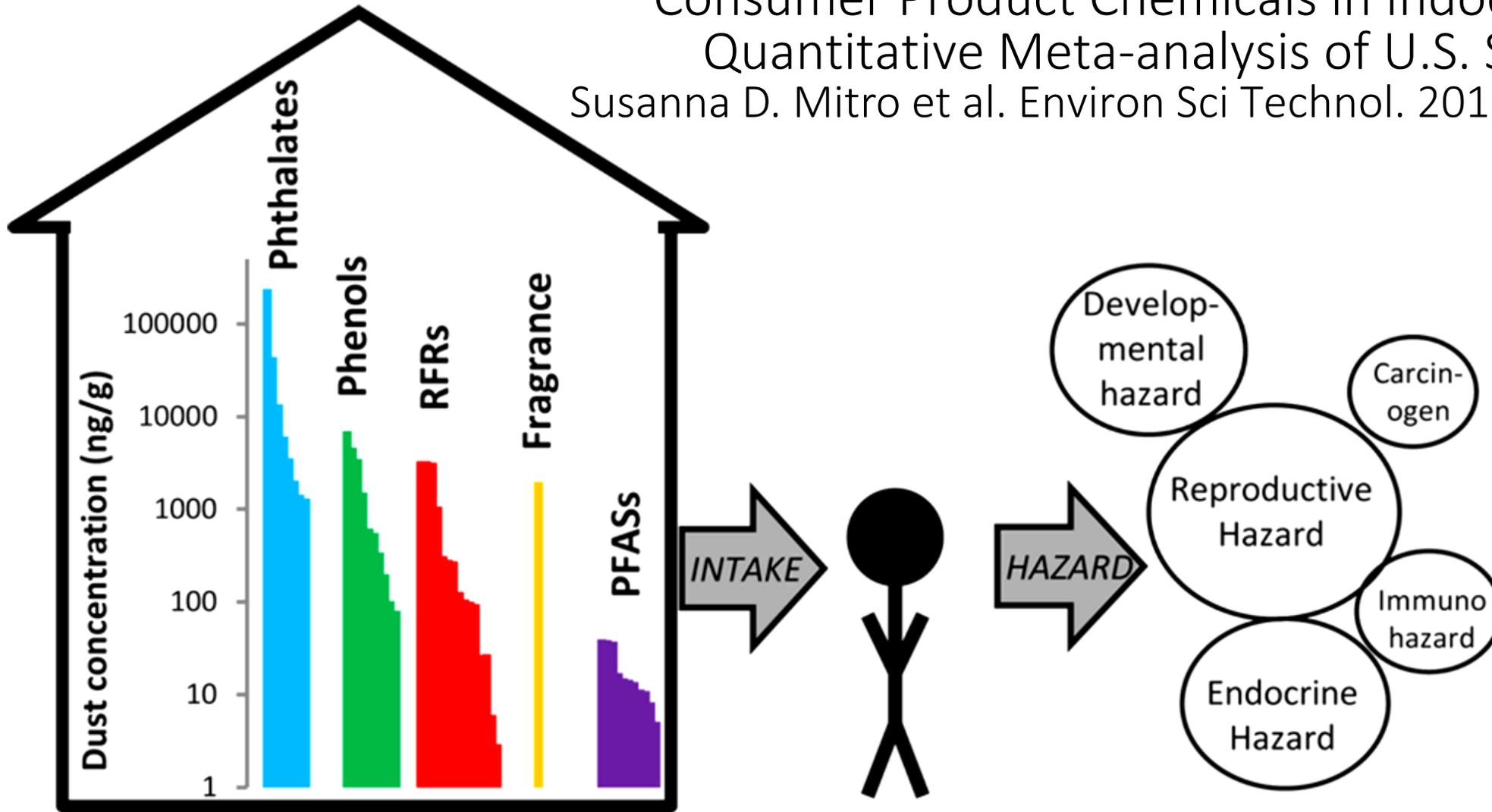
Each vertical bar represents one study participant. Other subsamples showed similar results



We found widespread exposure to pregnant women in the United States to multiple chemical analytes, including both banned and contemporary contaminants.

Many of these chemical analytes were similar to those measured in epidemiologic studies finding an association between prenatal chemicals exposure and adverse reproductive and developmental outcomes.

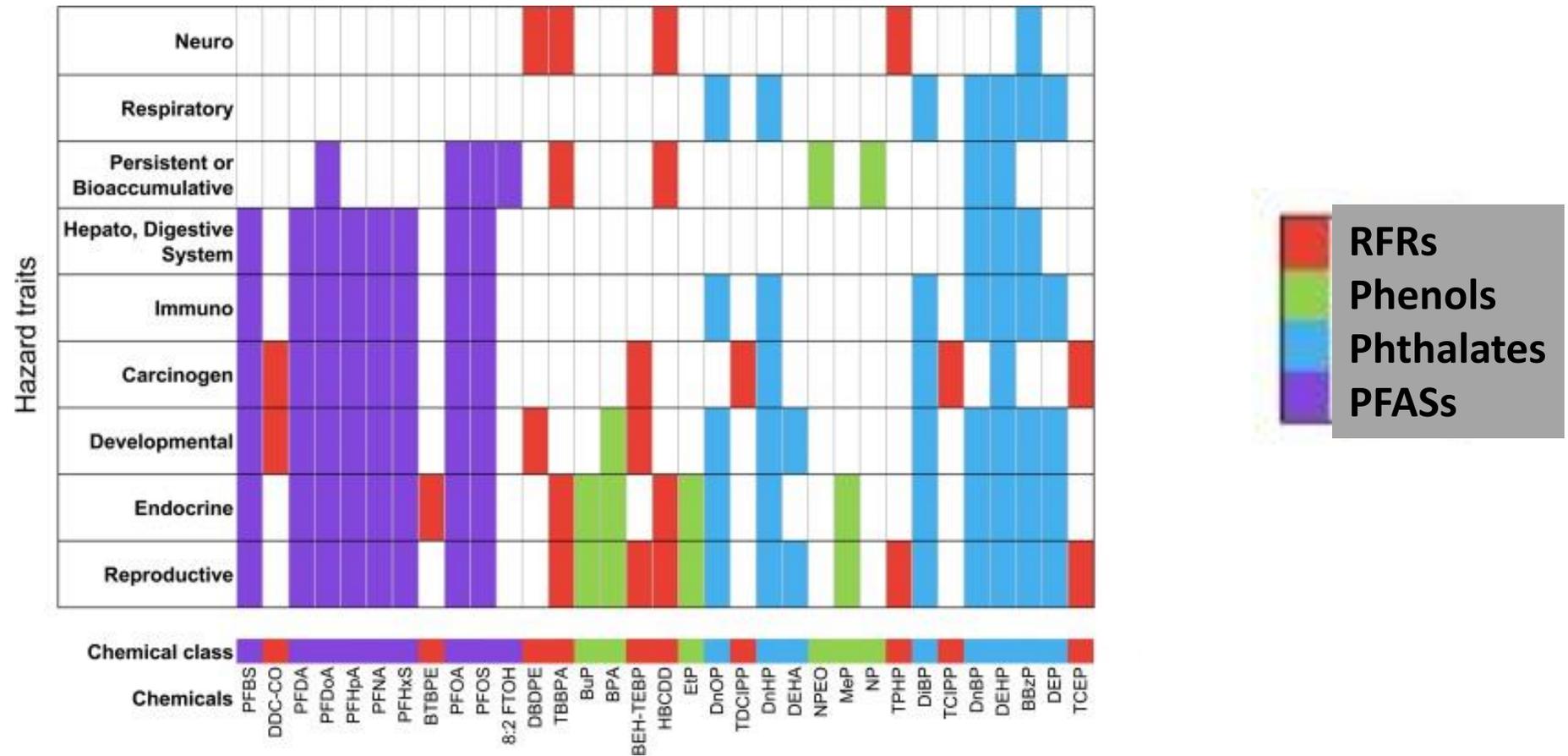
Consumer Product Chemicals in Indoor Dust: A
Quantitative Meta-analysis of U.S. Studies.
Susanna D. Mitro et al. Environ Sci Technol. 2016; 50: 10661-72



RFR: Replacement Flame Retardants
PFASs: Perfluoro-alkyl sulphonates

House dust is an important source of chemical
as well as biological pollution

Each row on the chart represents potential chemical hazard traits, and each column represents a chemical. Chemicals are listed in order of estimated adult daily residential intake (lowest intake on the left-hand side).



Consumer Product Chemicals in Indoor Dust: A Quantitative Meta-analysis of U.S. Studies. Environ Sci Technol. 2016; 50: 10661-72

April 2, 2017, Source: The Endocrine Society



Some flame retardants used in many home products appear to be associated with the most common type **of thyroid cancer, papillary thyroid cancer (PTC)**, according to a new study being presented Saturday at the Endocrine Society's 99th annual meeting, ENDO 2017, in Orlando, Fla.

"Thyroid cancer is the fastest increasing cancer in the U.S., with most of the increase in new cases being papillary thyroid cancer," said the study's lead investigator, Julie Ann Sosa, M.D., MA, professor of surgery and medicine at Duke University School of Medicine in Durham, N.C. **"Recent studies suggest that environmental factors may, in part, be responsible for this increase."**

"Our study results suggest that higher exposure to several flame retardants in the home environment may be associated with the diagnosis and severity of papillary thyroid cancer, potentially explaining some of the observed increase in the incidence of thyroid cancer," Sosa said. **"This study is novel in that we collected and analyzed individuals' house dust as a measure of exposure to flame retardants."**

Those were decabromodiphenyl ether (BDE-209), the most heavily used PBDE, and to a lesser degree, tris(2-chloroethyl) phosphate (TCEP), an organophosphate flame retardant. **Participants whose BDE-209 levels in their dust were high were more than two times as likely to have thyroid cancer than those individuals with low BDE-209 concentrations.**

Toxic fire-resistant sofas linked to surge in thyroid cancer

Jonathan Leake and Gareth Simkins

Scientists have warned that chemicals used to fireproof millions of British sofas could be linked to a surge in deadly thyroid cancer.

A conference next month will hear evidence that flame retardants such as decaBDE – decabromodiphenyl ether – used in most domestic sofas and mattresses, can cause cancer in adults and cognitive deficits in children.

It comes after government ministers were repeatedly warned by the civil servant in charge of furniture fire safety policy that the chemicals could be "deadly".

Terry Edge quit the Department for Business, Energy and Industrial Strategy (BEIS) last year after his proposals to restrict them were not implemented despite briefing civil servants and ministers since 2013.

"The evidence is clear that flame retardants in our sofas are killing people," said Edge. "They are causing thousands of cancers and other illnesses, with children particularly vulnerable."

Next month's symposium on flame retardants in York will be told of evidence linking the chemicals with thyroid cancer, rates of which have risen 74% in a decade, according to Cancer Research UK.

"The chemicals are released as household dust and enter our bodies on our food and hands, with the highest levels in children," said Heather Stapleton of Duke University in North Carolina, who is a speaker at the symposium.

"Our study looked at people with thyroid cancer and at healthy controls. We found the group with cancer had significantly higher exposure to decaBDE."

The scientists found that exposure in pregnancy or

before the age of four was linked to cognitive deficits.

This month a meeting of signatories to the Stockholm convention, a UN treaty to restrict pollutants, is set to ban most uses of decaBDE, with existing products deemed hazardous waste.

The UK is a signatory and supports the ban.

"If our science committee's recommendations are agreed then at the end of their life, products containing decaBDE become hazardous waste and cannot be recycled," said Kei Ohno Woodall, of the convention secretariat.

Asked about sofas and mattresses, she said: "They must be burnt in a high-temperature incinerator or buried in a waterproof landfill engineered to stop the contents leaching out."

74%

Increase in thyroid cancer cases over the past decade

The BEIS said it was unable to comment on ministerial briefings. "We are developing new regulations to keep pace with changes to manufacture and consumer tastes," it said.

Jonathan Hindle of the British Furniture Confederation, said concerns about decaBDE meant it was being phased out. "We are aware of the potential waste disposal issue... and will work with the authorities."

The British Plastics Federation, whose members include retardant makers, said the ruling would create waste problems owing to the presence of decaBDE "in a lot of furniture in the UK".

@jonathan_leake

An indoor chemical cocktail

The chemistry that determines human exposure to indoor pollutants is incompletely understood - Sasho Gligorovski S, Abbatt JPD. *Science* 2018: Feb 9 359; 632-3



- Recent work has highlighted the wealth of **chemical transformations** that occur indoors.
- This chemistry is associated with 3 of the top 10 risk factors for negative health outcomes globally: **household air pollution from solid fuels, tobacco smoking, and ambient particulate matter pollution.**
- Highly oxidized organic compounds arise via auto-oxidation mechanisms initiated by either ozone or radical attack.
- Reaction with a single oxidant molecule can form multiple oxygenated functional groups on an organic reactant within seconds, changing it from a volatile gas to a molecule that will condense to form **secondary organic aerosol (SOA) particles.**

Clear the air for children: The impact of air pollution on children.



October 2016



Together, outdoor and indoor air pollution are directly linked with pneumonia and other respiratory diseases that account for almost one in 10 under-five deaths, making air pollution one of the leading dangers to children's health.



Royal College
of Physicians

Setting higher standards

Impact of Indoor Air Quality on Children's Health across the Life Course



In April 2017 the RCPCH hosted a workshop “Better homes, better air, better health” bringing together professionals across research, industry and the third sector.

The workshop highlighted the need to strengthen understanding of the relationship between indoor air pollution exposure and health impacts, identify solutions to help tackle and reduce indoor generated air pollution and communicate this information clearly to the public.

Impact of Indoor Air Quality on Children's Health across the Life Course



What next?

In light of this, the RCPCH is proposing to undertake a 17-month project to produce an evidence based report on the impact of indoor air pollution on children's health in the UK.

The project aims to start in 2018, and a working group will be established to commission systematic evidence reviews and drive the development of the report with the ultimate aim to raise awareness of the issues affecting the health of children exposed to indoor air pollution, generated outdoors and indoors, and develop evidence based solutions.

Impact of Indoor Air Quality on Children's Health across the Life Course



The report will aim to:

- Raise awareness of the issues affecting the health of children exposed to indoor air pollution generated outdoors and indoors.
- Expeditiously develop evidence-based solutions focussed on;
- Improving the health of children
- Attenuating the consequences of exposure in childhood on health effects across the life course
- Influence the renovation of current housing stock, and the planning and building of new homes in order to mitigate risk
- Use of existing and novel systems and technology to further mitigate exposure
- Highlight potential effects of climate change on this problem.

Impact of Indoor Air Quality on Children's Health across the Life Course



Help us improve the air they breathe

We're seeking **your help** to produce an evidence based report on the impact of indoor air pollution on children's health in the UK. Please consider making a donation or contributing in kind or with evidence to provide for advancing our work in this area of child health - making a real difference to the lives of children and their families here in the UK and across the world.

Support so far



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RCPCH

Royal College of
Paediatrics and Child Health

Leading the way in Children's Health

Dyson: Literature review

dyson



Can industry help by rising to this challenge?



bre



Indoor Air Pollution

Is Worse Than You Think



7 million

people die each year - 1 in 8 of total global deaths – as a result of air pollution exposure



Women who work in the home have a **54% higher death** rate from cancer than women who work outside the home

600,000

Number of children under age five that die every year from diseases caused by outdoor and indoor air pollution



2x-5x

more pollution found indoors that outdoors



Most people spend **90%** of their time indoors



96%

of homes have at least one indoor air quality problem



Indoor air quality is one of the top **five environmental risks** to public health