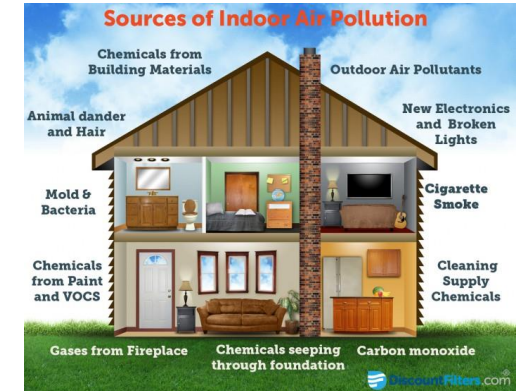


Ventilation, indoor air quality and human health
Stephen T Holgate, Faculty of Medicine, University of Southampton.

RCP Special Advisor on Air Quality



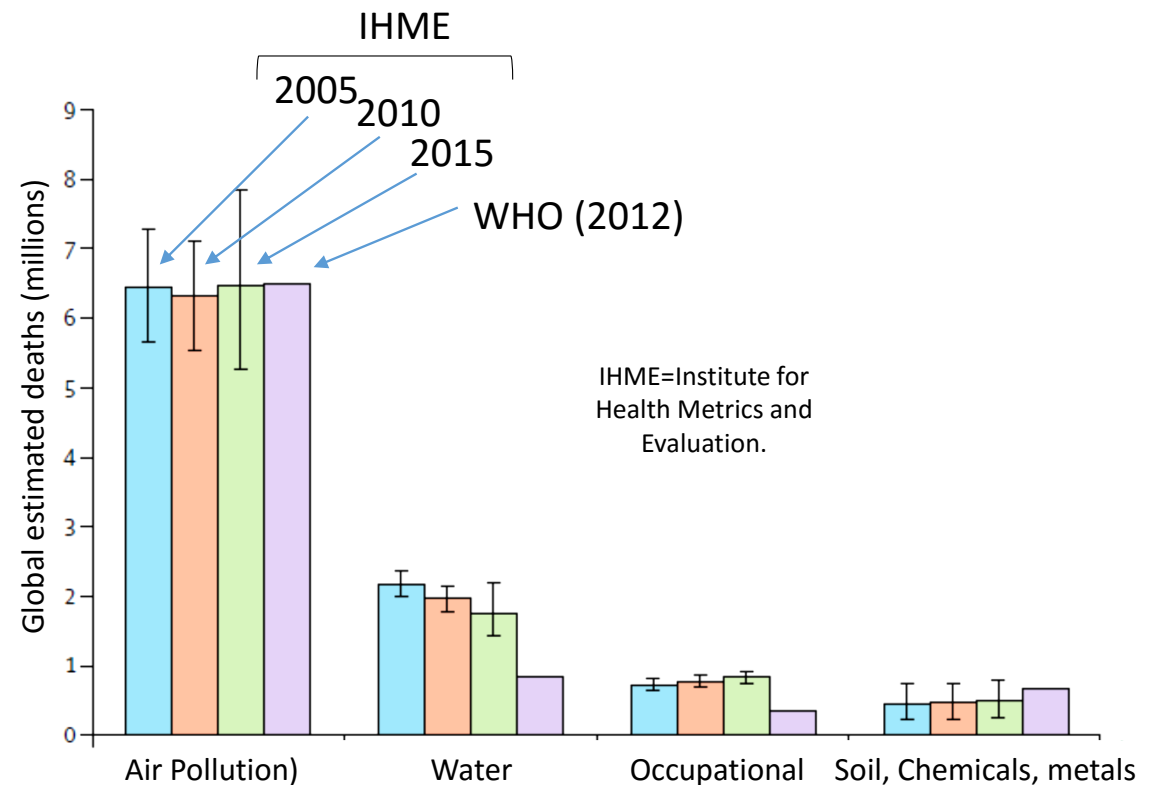
Global estimated deaths (millions) by pollution risk factor, 2005-15

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)

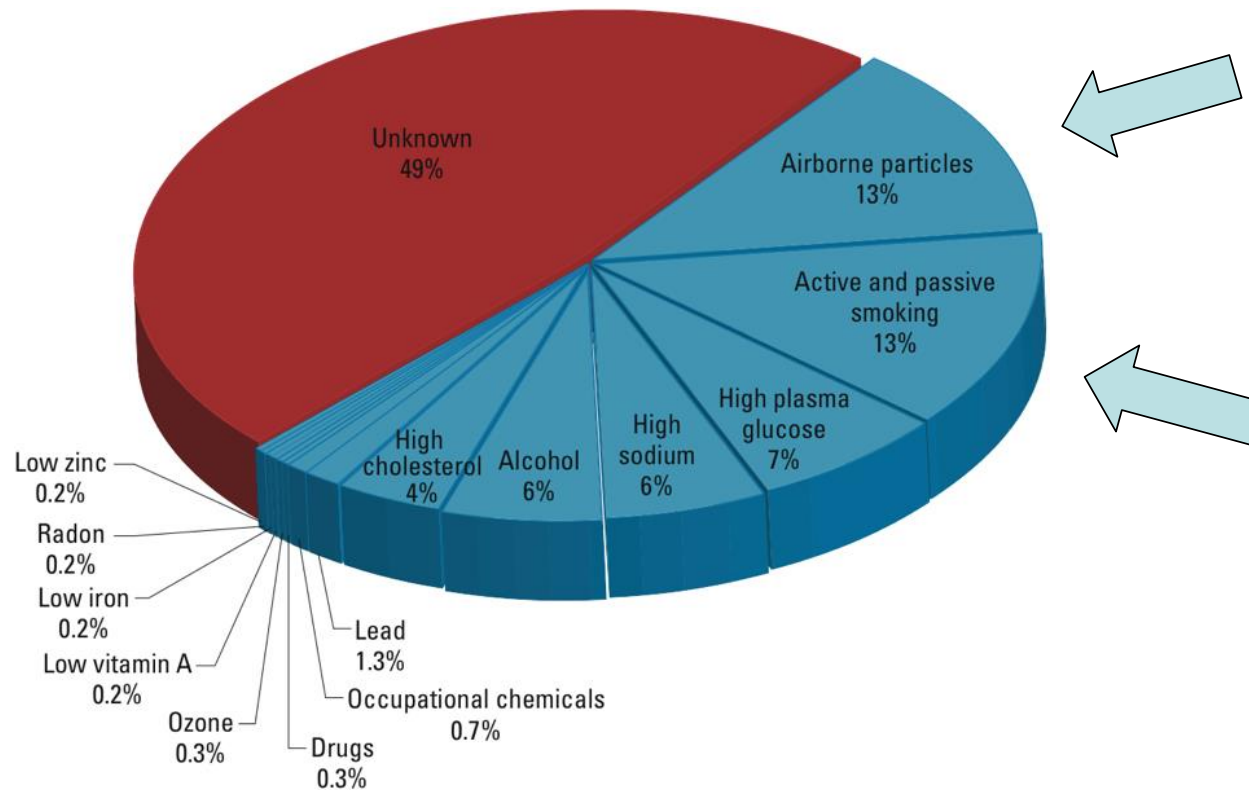
	GBD study best estimate (95% CI)	WHO best estimate (95% CI)
Air (total)	6.5 (5.7-7.3)	6.5 (5.4-7.4)
Household air	2.9 (2.2-3.6)	4.3 (3.7-4.8)
Ambient particulate	4.2 (3.7-4.8)	3.0 (3.7-4.8)
Ambient ozone	0.3 (0.1-0.4)	..
Water (total)	1.8 (1.4-2.2)	0.8 (0.7-1.0)
Unsafe sanitation	0.8 (0.7-0.9)	0.3 (0.1-0.4)
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.



The *Lancet* Commission on pollution and health

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

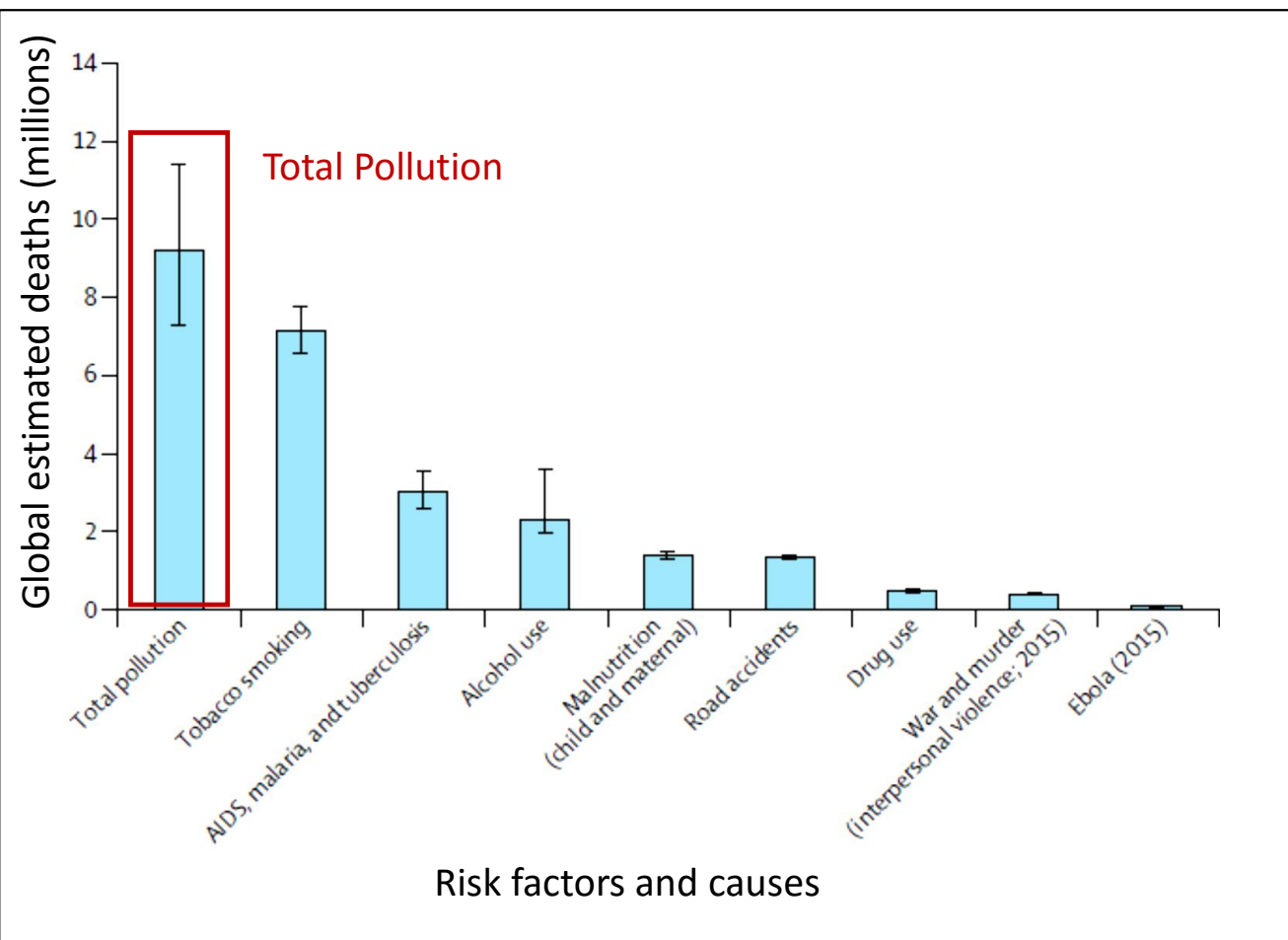
Source: World Health Organization figures, 2012

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



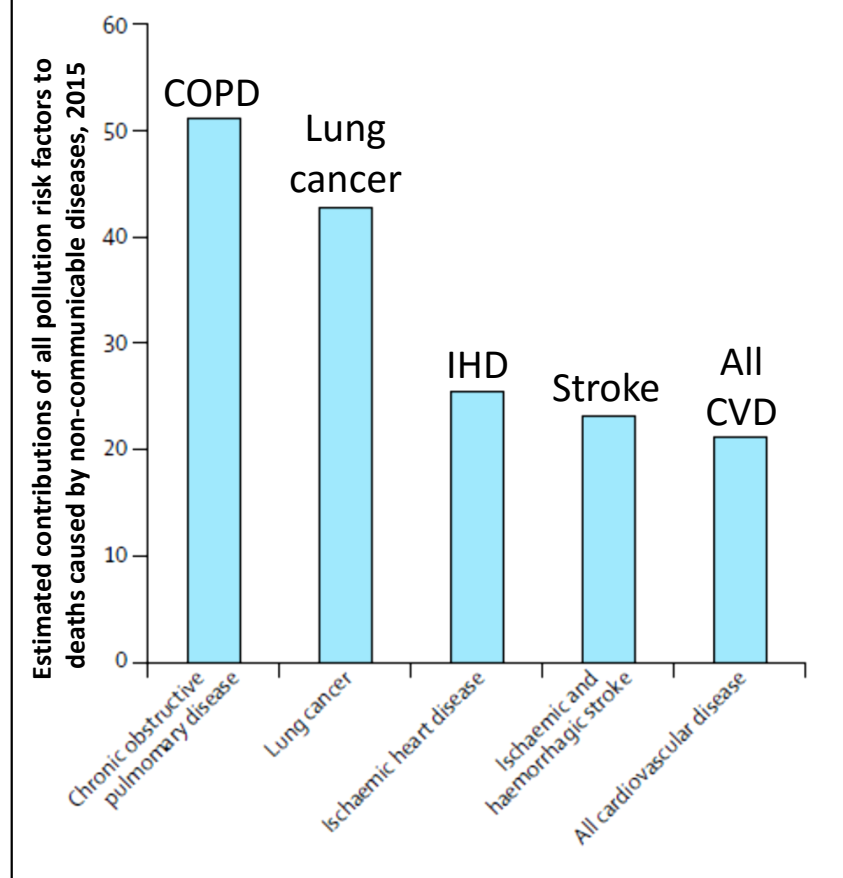
Global estimated deaths by major risk factor and cause, 2015

Using data from the GBD Study, 2016.



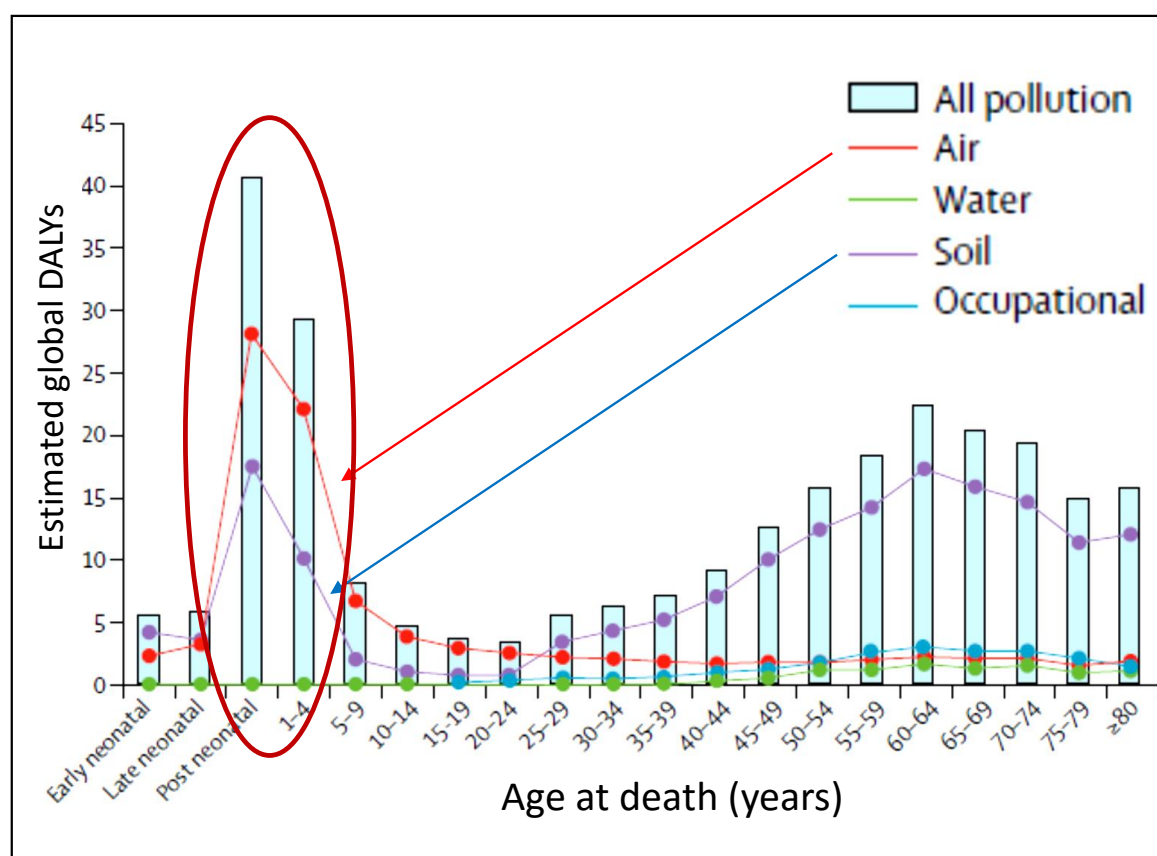
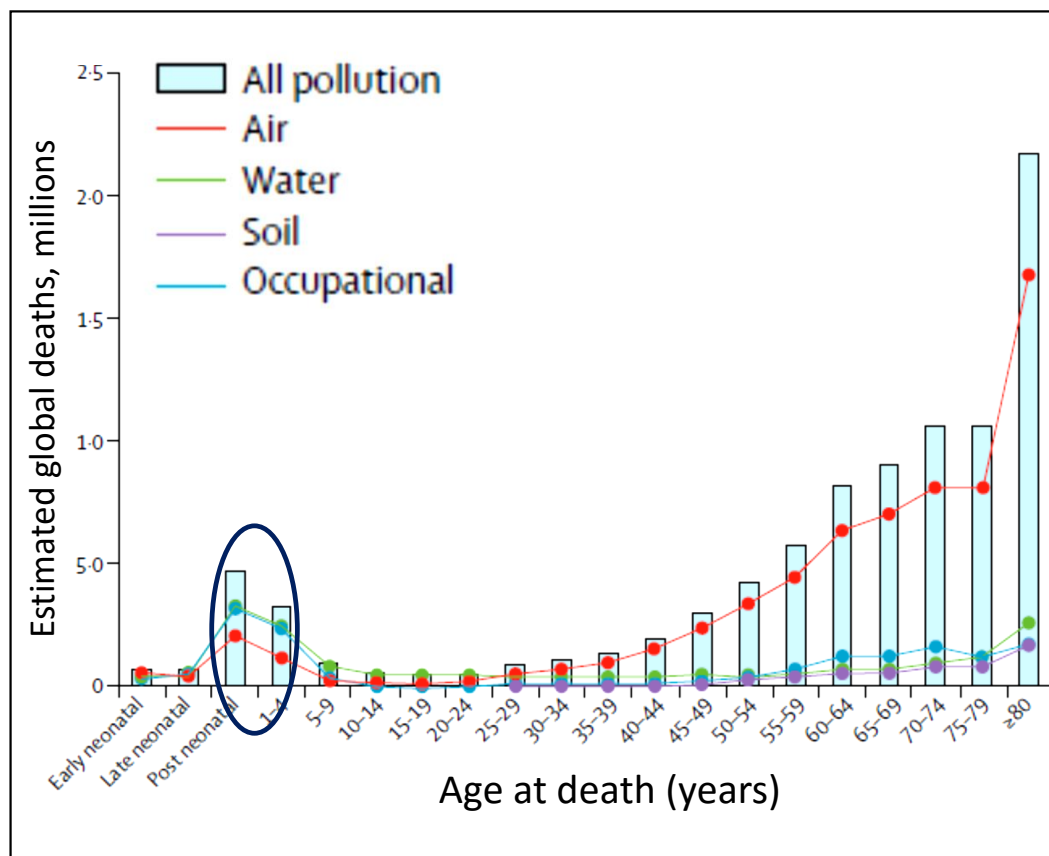
The *Lancet* Commission on pollution and health

Estimated contributions of all pollution risk factors to deaths caused by non-communicable diseases, 2015



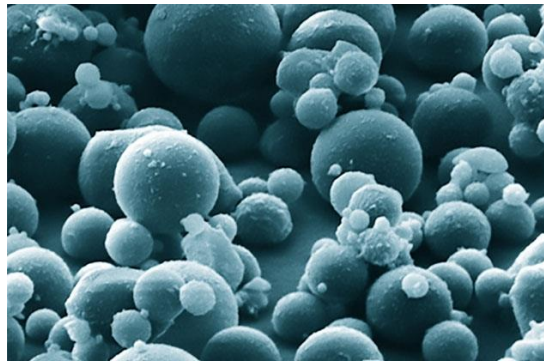
Estimated global deaths (left) and global Disability Adjusted Life Years (DALYs, right) by pollution risk factor and age at death by pollution risk factor, 2015
WHO GBD Study, 2016.

The *Lancet* Commission on pollution and health

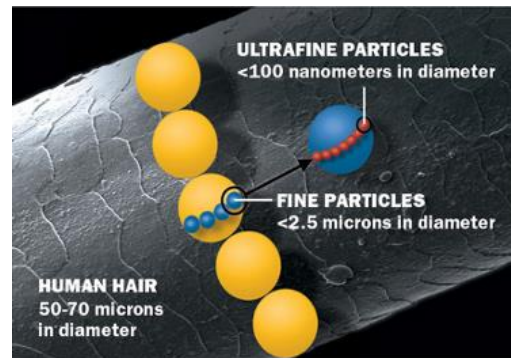


Types of outdoor air pollution: NO_2 , Ozone (O_3), SO_2 , Particles and PAHs

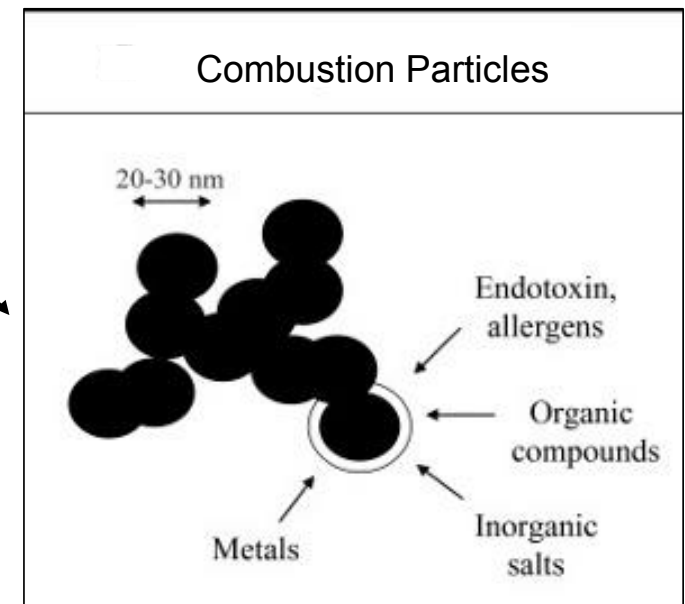
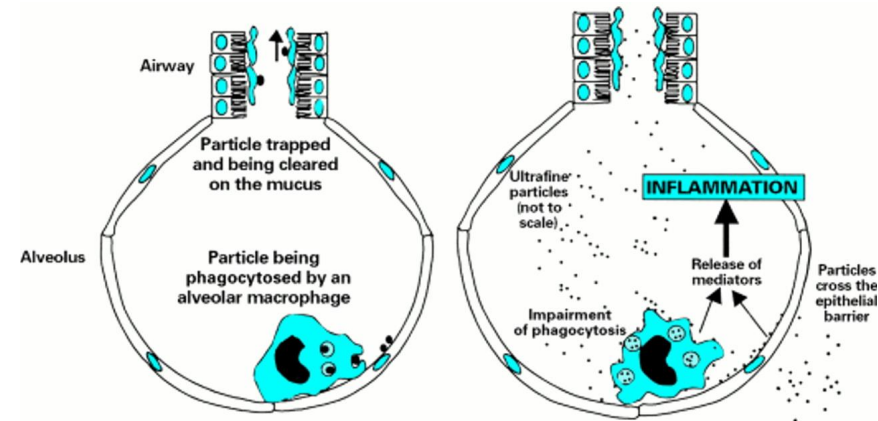
Particulates



Particle air pollution remains the greatest concern: PM_{10} , $\text{PM}_{2.5}$ and $\text{PM}_{0.1}$



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

Why the RCP is tackling this issue?

- Since February 2016, considerable progress is being made.
- RCP held Ministerial Round Table, March 2018 to take stock and move forward
- Defra to announce new Air Quality Strategy next week
- PHE/ IC Business School to release report on the Economics of Pollution May 2018

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%)

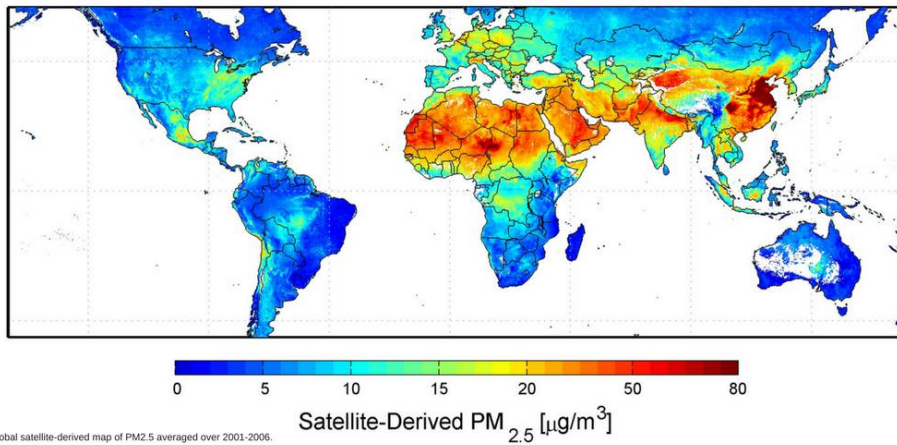


Indoor air pollution in Asia

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

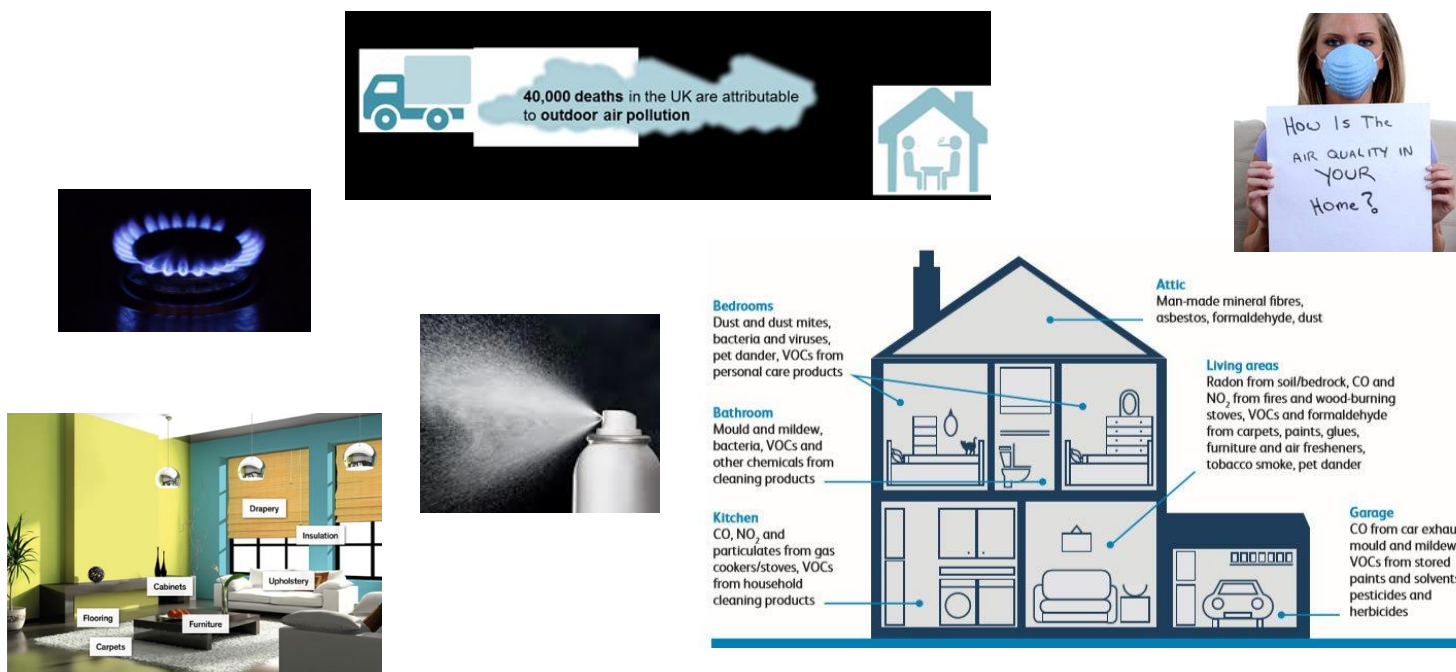


Health Effects of Indoor Air Pollution

- 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



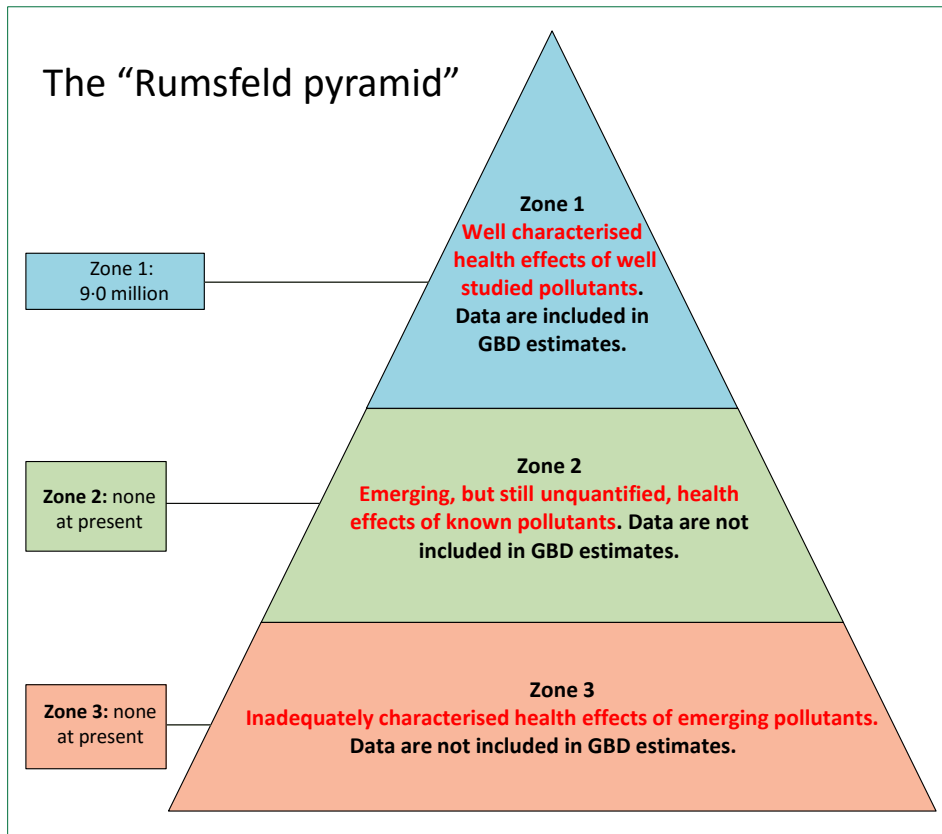
11. Quantify the relationship between indoor air pollution and health. We must **strengthen our understanding of the relationship between indoor air pollution and health**, including the key risk factors and effects of poor air quality in our homes, schools and workplaces.

A coordinated effort among policymaking bodies will be required to develop and apply any necessary policy changes

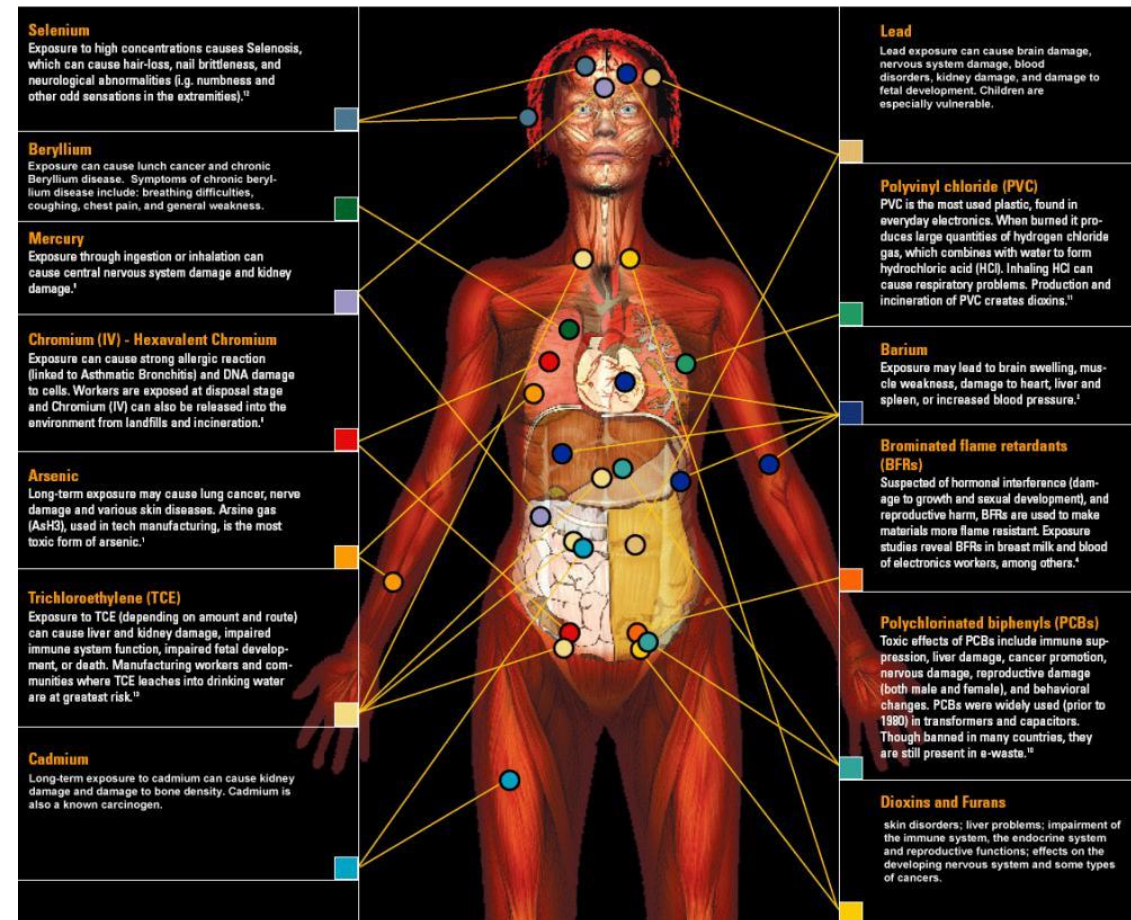
“The Pollutome”

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)



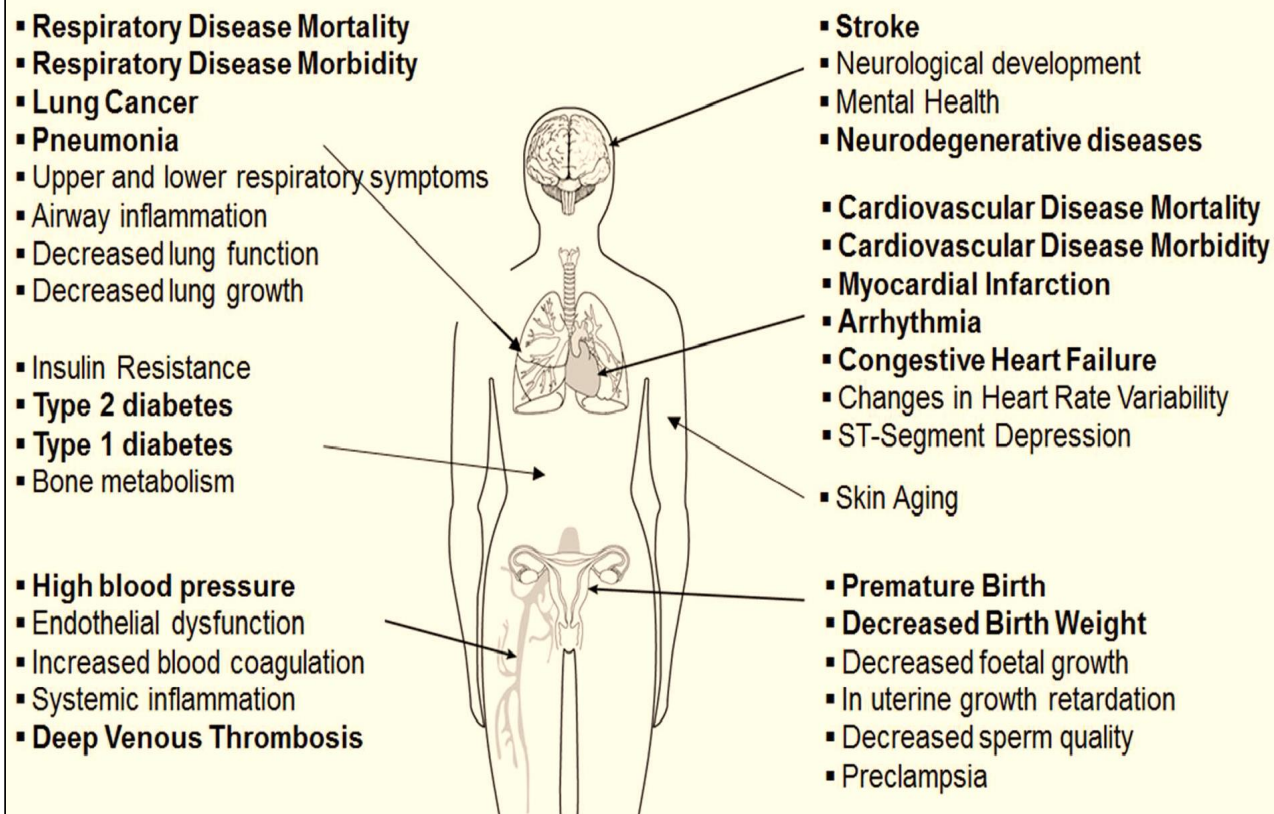
The *Lancet* Commission on pollution and health



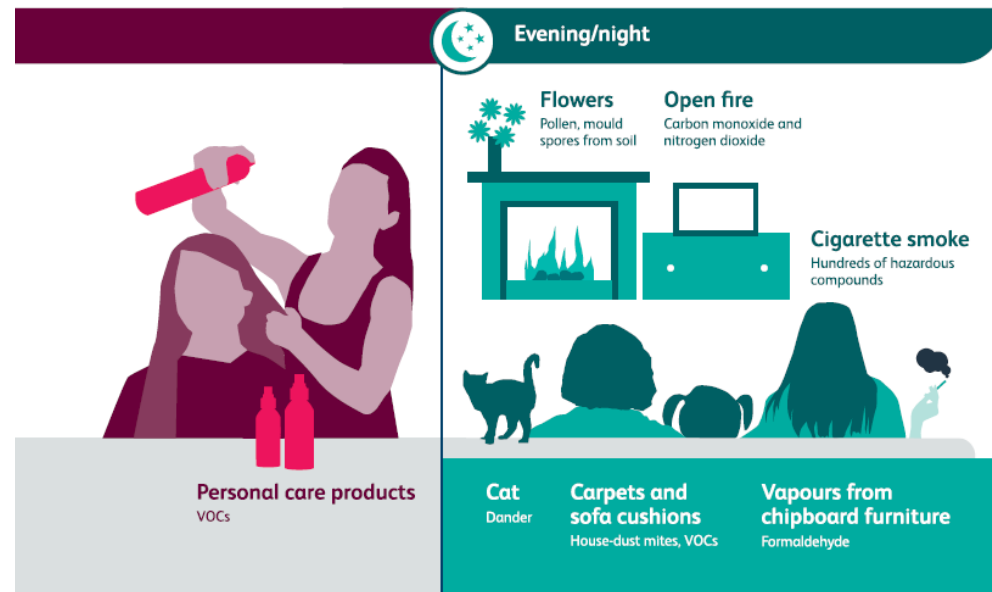
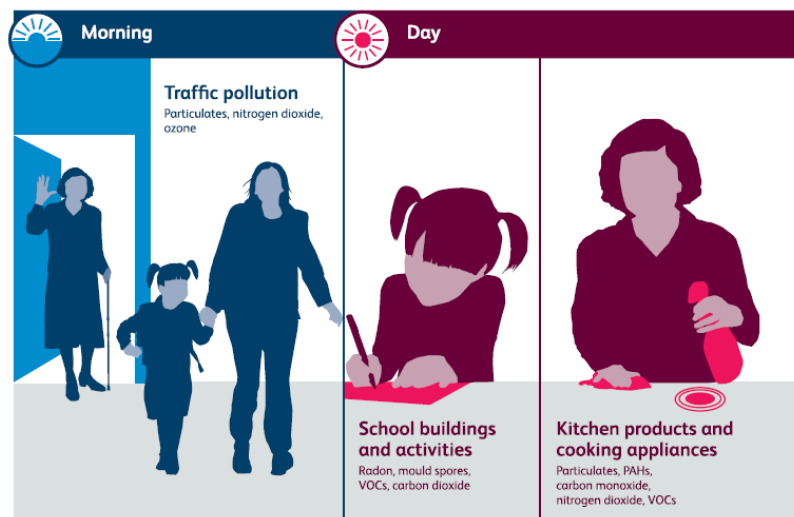
Overview of diseases, conditions, and biomarkers affected by outdoor air pollution.

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

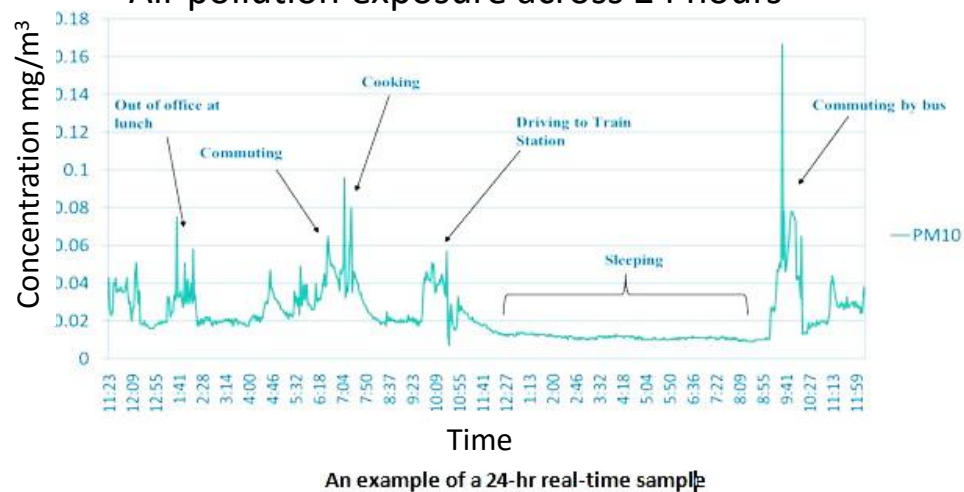
An ERS & ATS Policy Statement: Aug 2016: What Constitutes an Adverse Health Effect of Air Pollution? An analytical framework



Health effects of pollutants across 24 hours/day of exposures



Air pollution exposure across 24 hours



Indoor air pollution sources shown include: Paint, Kerosene Heater, Mothballs, Fresh Dry Cleaning, Carpeting, Curtains, Plywood, Gas Range, Fireplace, Foam Padding, Asbestos Insulation, Heating, Disinfectants, Pesticides, Cleaners, Solvents, Aerosols, Glues, Carbon Monoxide, RADON, and various cleaning products like Pledge, Soft Scrub, and Resolve.

Chemical structures shown: Formaldehyde (CH2=O), Carbon Monoxide (C#O), and a flame retardant structure.

Text: "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



Paints, pesticides, and other consumer products now add as much to air pollution as cars

Volatile chemical products emerging as largest petrochemical source of urban organic emissions.
McDonald BC, et al. Science. 2018; 359: 760-764.

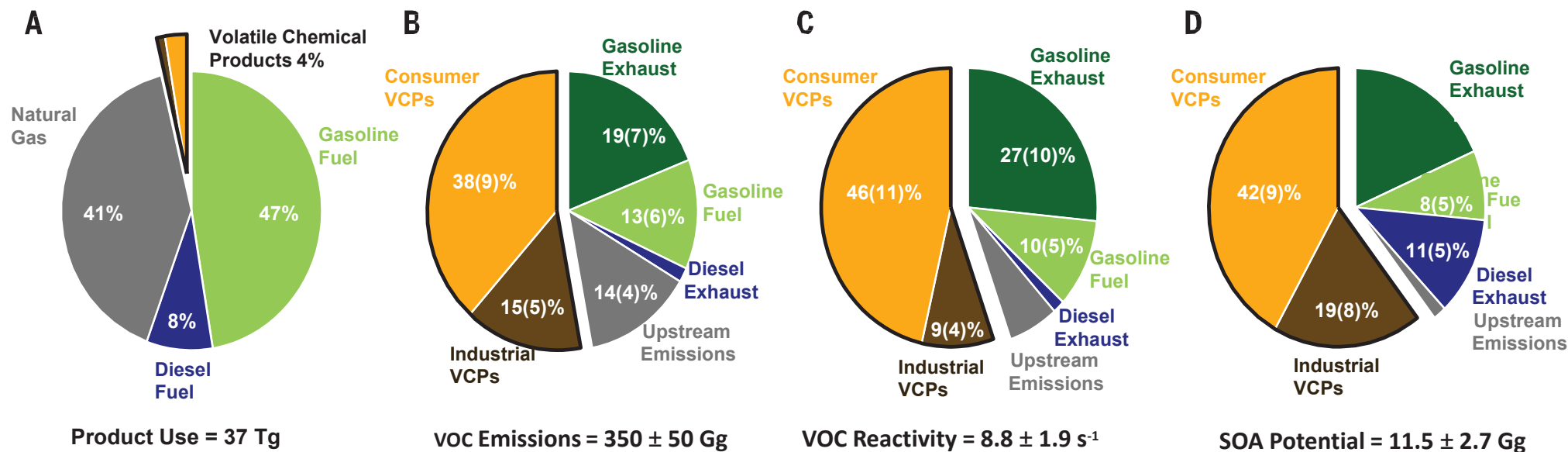
- Chemical productions statistics from industrial and government agencies - pesticides, coatings, inks, adhesives, and personal care products such as perfumes produce >2x the emissions of cars.
- U.S. inventories underestimate VOC emissions from these products by a factor of three, while overestimating car VOC emissions by 40%.
- Because most people use the products that make VOCs indoors, the researchers also compared emissions from residential and commercial buildings to outdoor measurements in LA, Cal.
- Concentration of VOCs compounds indoors was **7-times higher than in ambient air.**

Air pollution is increasingly from consumer and industrial products rather than from the transportation sector. These products are used indoors where people spend most of their time, which means their use poses a health risk that requires updated regulations.

Contributors to ambient air pollution in Los Angeles

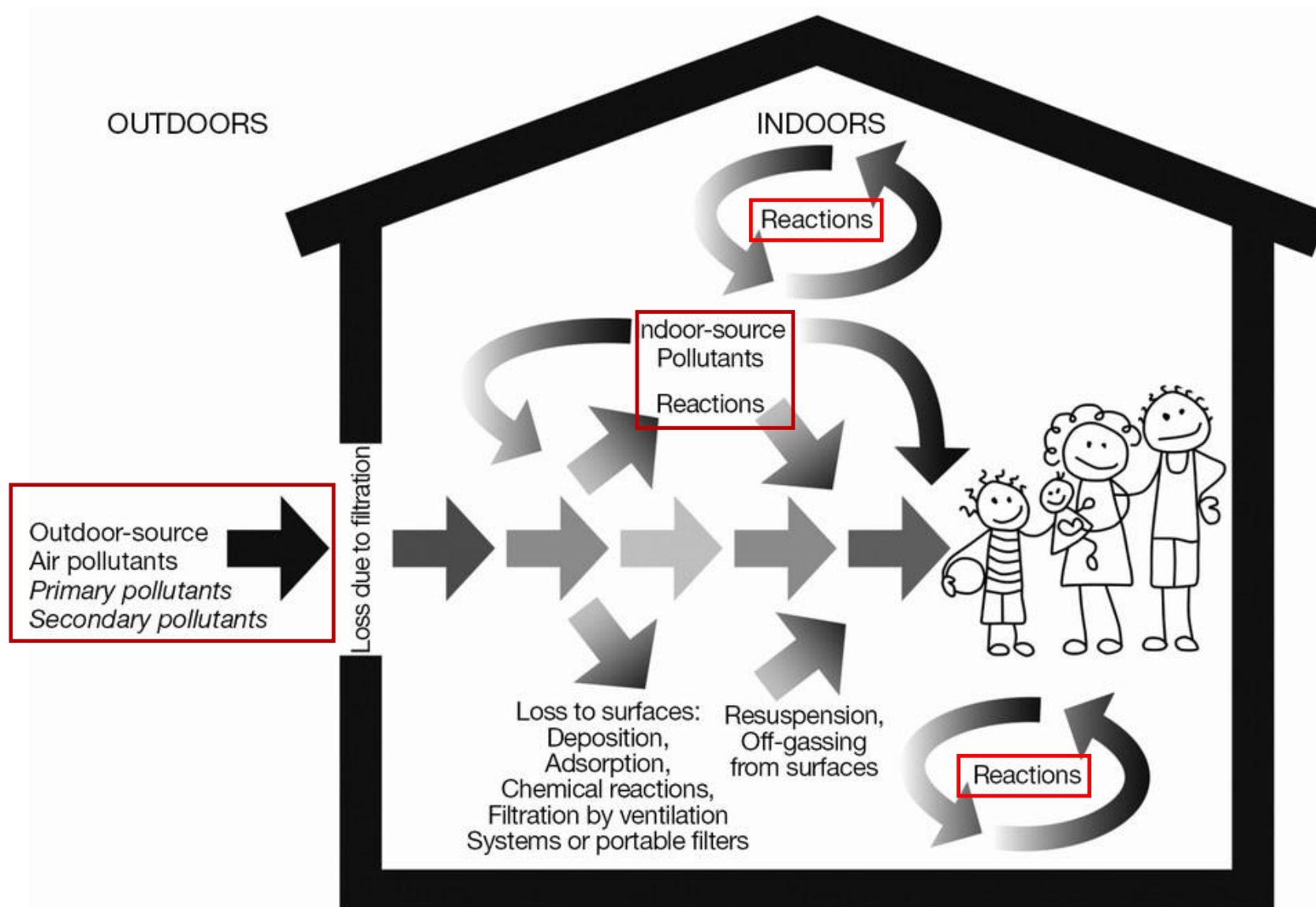
McDonald BC, et al. Science. 2018; 359: 760-764.

Distribution of (A) petrochemical product use, (B) VOC emissions, (C) VOC reactivity with OH, and (D) Secondary organic aerosols (SOA) [a major component of fine particulate matter (PM_{2.5}) in cities] formation potential across petrochemical sources only. Contributions from non-fossil sources are not shown.



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

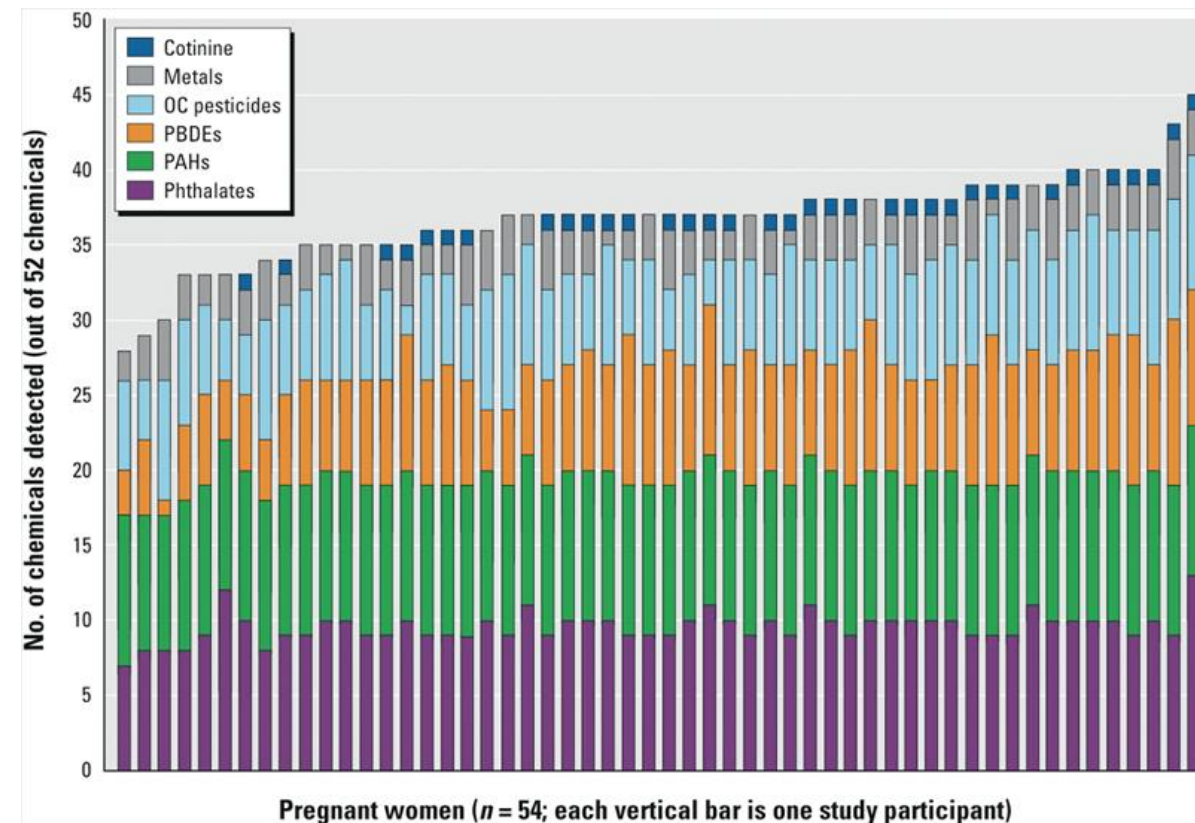


Environmental Chemicals in Pregnant Women in the United States: NHANES 2003–2004

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).

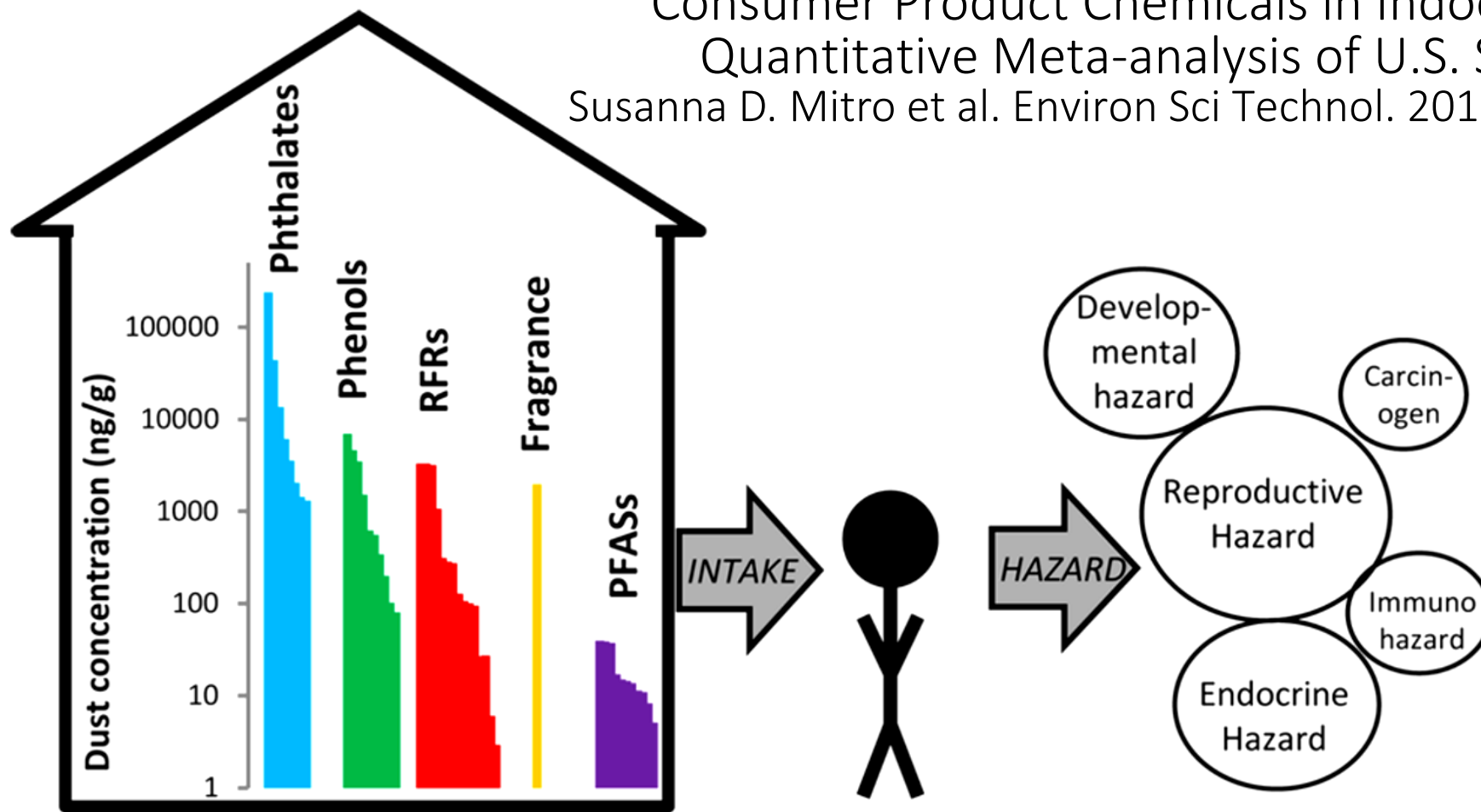
Each vertical bar represents one study participant. Other subsamples showed similar results



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.

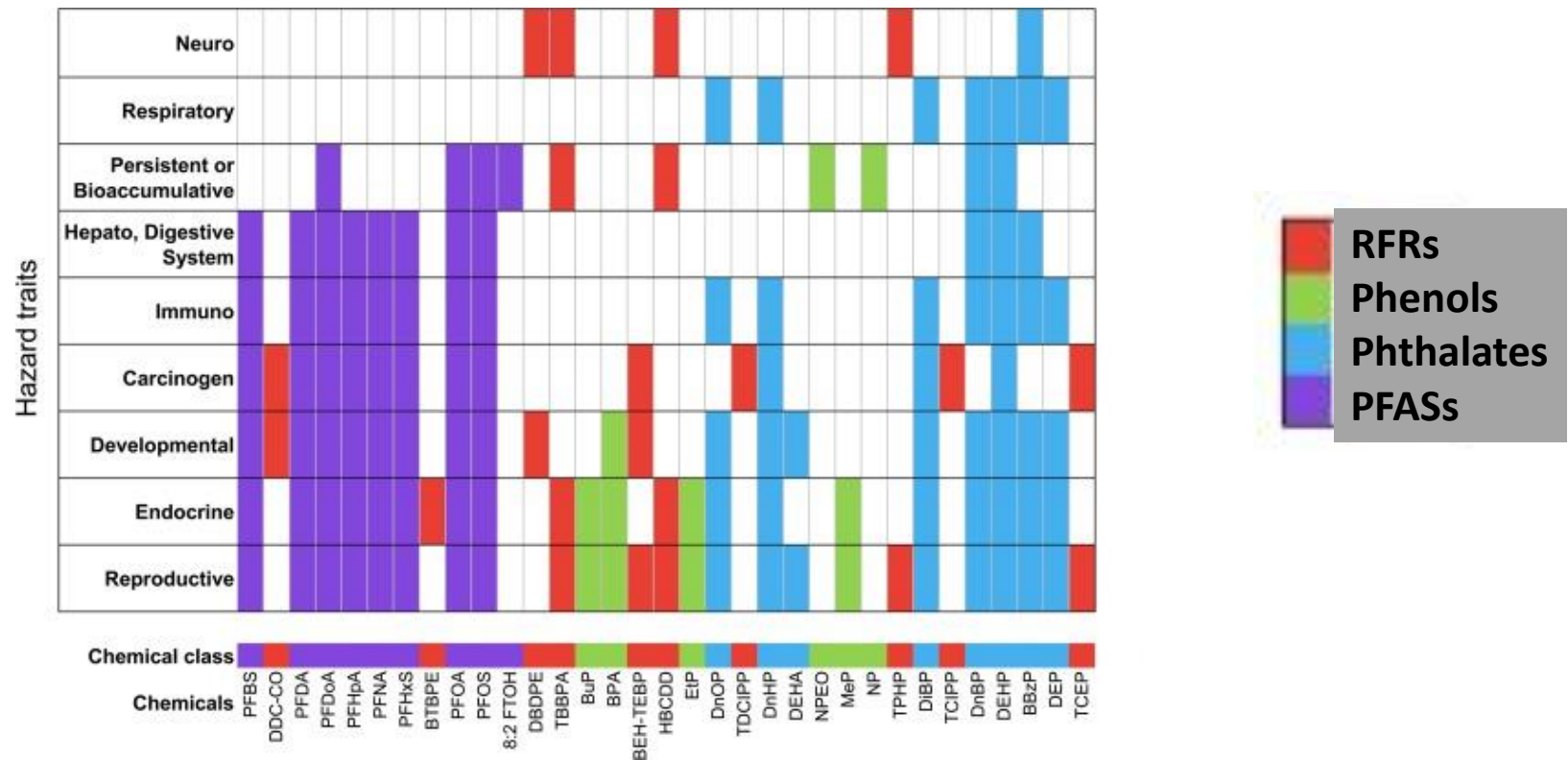
Consumer Product Chemicals in Indoor Dust: A
Quantitative Meta-analysis of U.S. Studies.
Susanna D. Mitro et al. Environ Sci Technol. 2016; 50: 10661-72



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

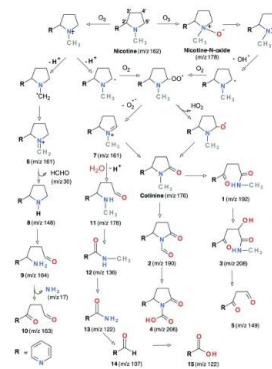
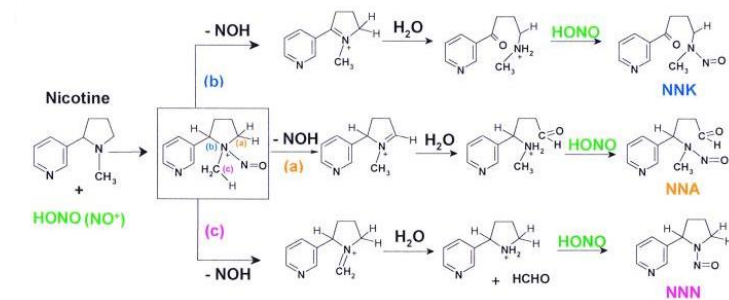
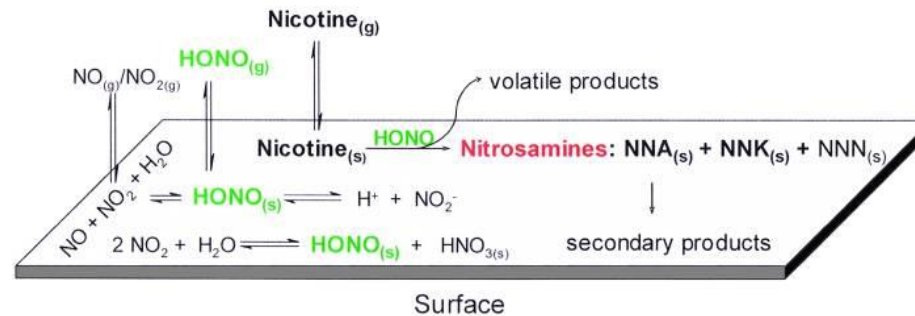


- Recent work has highlighted the wealth of **chemical transformations** that occur indoors.
- This chemistry is associated with 3 of the top 10 risk factors for negative health outcomes globally: **household air pollution from solid fuels, tobacco smoking, and ambient particulate matter pollution.**
- 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.**

Third-hand Smoke: New Evidence, Challenges, and Future Directions

Jacob P 3rd et al. Chem Res Toxicol. 2017; 30: 270-94.

Third-hand smoke is residual - or leftover - nicotine and other chemicals that remain on clothing and surfaces after someone smokes in the area. Dangerous residue from tobacco smoke sticks to carpets, walls and other surfaces after the smoke clears.



Nicotine reactions with ozone

1. Third-hand smoke may be a culprit in more cancer cases
2. Third-hand smoke may damage DNA
3. Residue may react with airborne chemicals to form carcinogens
4. Children are most at risk
5. Removing the residue is very difficult

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

Annual Report of the Chief Medical Officer 2017

Health Impacts of All Pollution.

Pollution, most particularly air pollution, is receiving a great deal of attention in the United Kingdom at the moment. However, tackling pollution (in all its forms) has not been foremost in the minds of health policy makers in recent years. It has been the role of public health professionals of all disciplines, and the wider public health workforce, to guard the public from the health impacts of pollution.



- **Recommendation 9**

...We must further expand this focus to indoor air. Work to gather evidence of health impacts, raise awareness of any harm and highlight actions to address this is needed, just as the Royal College of Paediatrics and Child Health/Royal College of Physician Working Group on indoor air quality and child health proposed.

- **Recommendation 10**

I recommend that Department for Environment, Food and Rural Affairs investigate the availability and quality of (low cost) indoor air pollution monitors, publishing their results, in order to support the public's use of home air quality monitoring equipment.

- **Recommendation 11**

I recommend that industry leaders should work to be more transparent about the polluting effect of their activities, strive to reduce this effect, using innovative interventions, and bring success and best practice to attention within their industry.

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 focused upon;

- 1) Improving the health of children
- 2) Attenuating the consequences of exposure in childhood on health effects across the life course
- 3) Influence the renovation of current housing stock, and the planning and building of new homes in order to mitigate risk
- 4) Use of existing and novel systems and technology to further mitigate exposure
- 5) 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



Royal College
of Physicians

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