Public Health England 2019

UK review on outdoor and indoor air pollution research

PREPARED FOR

Alliance for Sustainable Building Products

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HEALTHY
DEVELOPMENTS

1 INTRODUCTION

1.1 Professor Paul Cosford, Director for Health Protection and Medical Director, Public Health England.

1.2 Public Health England (PHE) have two tag lines that have garnered much press attention, “Clean by Design” and “Pollution Free Generation”.

1.3 Looking to focus on the next generation to leave a clean and pollutant free environment.

1.4 Current climate regarding talking about air quality has dramatically improved in the past three years, where the topic is no longer a ‘nanny state’ topic of conversation. Feels like we are at an inflexion point.

1.5 A government commission has been created to see if the clean air strategy will actually have an effect.

1.6 There is still a lot to do, particularly around people’s behaviour, such as car engines turned out when sat idle.

1.7 Every school in London has exposure levels above the World Health Organisation’s (WHO) guidelines.

1.8 Research on indoor air pollution (IAP) is lagging research on external air pollution (EAP).

1.9 We have existing knowledge and technology to tackle the problem of air pollution.

2 AIR POLLUTION AND BIRTH OUTCOMES: A LOOK AT THE EPIDEMIOLOGICAL EVIDENCE, AND FINDINGS FROM THE TRAFFIC POLLUTION AND HEALTH IN LONDON STUDY

2.1 Dr Rachel B. Smith, Research Associate, Department of Epidemiology and Biostatistics, Imperial College London.

2.2 There are four types of birth outcomes that we are concerned with: restricted foetal growth (7% of all live births have a low birth weight); pre-term births (8% of all live births); stillbirths (4.2 per 1,000 total births); and congenital anomalies (structural, chromosomal, cleft lip, down syndrome).

2.3 Congenital anomalies can lead to poor foetal growth and increase the risk of infant mortality.

2.4 Low birthweight can increase infant mortality, increase complications and increase health problems later in life.

2.5 Air pollution & birth outcomes:

2.6 There has been a surge in research on the topic, particularly coming from China.

2.7 Strong evidence for a correlation between particulate matter (PM) and birth weights.

2.8 Some evidence, but less so, for nitrogen dioxide (NO_2), Sulphur Dioxide (SO_2) & Carbon Dioxide (CO_2).

2.9 No evidence for a relationship with ozone.

2.10 A Chinese study showed 8 month of pregnancy proves a critical window for negatively associating PM with birth weights.

2.11 Most research uses a single-pollutant model.

2.12 Pedersen et al. (2013) show association with low birth weights and NO_2 is largely attenuated by PM data when a multi-pollutant model is used.

2.13 Air pollution & pre-term birth:

2.14 $PM_{2.5}$ shows an increased risk of pre-term birth.

2.15 Ozone and SO_2 have less evidence. ESCAPE study shows no relationship.

2.16 Pre-term birth is complicated to study.

2.17 There seems to be a higher risk in 2nd trimester for exposures to PM & NO_2 with pre-term births. Ozone has a similar peak in 2nd trimester but also has one in the 1st trimester.

2.18 Air pollution & stillbirths:

2.19 Far less research. Only 1 meta-analysis study and this only based on 3 studies.

2.20 The highest association is with PM, some association with NO_2 but not other pollutants.

2.21 Summary: fine PM has a strong association with restricted foetal growth and low birth weight.

2.22 Rachel's study looks at long term exposure to traffic-related air and noise pollution in relation to birth outcomes in London:

2.23 Barely any studies on this that look at how much can be attributed to negative birth outcomes to noise pollution from traffic versus air pollution from traffic.

2.24 Area of scope was within the entire M25 circular.

2.25 Kings college used dispersion modelling for air and noise was split into daytime and night time. The outcome data was sourced from national birth registers.

2.26 Results:

2.27 Birth weights were correlated to both noise and air pollution when they were assessed individually. However, in models that assess the impact of both sources of pollution at the same time, noise pollution was attenuated by the air pollution data.

2.28 Similarly, when looking at the individual air pollutants, NO_2 was attenuated by PM data. Therefore, they conclude PM is what is driving the impact on BW.

2.29 Preterm birth impacts (unpublished to date) shows a similar pattern. However, only the 1st trimester seemed to be the point when the preterm birth is influenced.

3 AIR POLLUTION & ASTHMA ADMISSIONS IN LONDON

3.1 Dr Heather Walton, Senior Lecturer in Environmental Health, King's College London.

3.2 A similar study was carried out in NYC.

3.3 This was a health impact assessment (HIA) study that pooled studies to form a meta-analysis.

3.4 The HIA uses single pollutant model estimates only for $PM_{2.5}$ and NO_2.

3.5 Meta-analysis process used only 1 estimate per study location.

3.6 No evidence between $PM_{2.5}$ and asthma admissions. There was some evidence for an association with asthma admissions and NO_2.

3.7 With regards to NO_2, asthma admission was more likely in children and elderly compared to adults.

3.8 For ambient air pollution, concentration levels of $PM_{2.5}$ are more constant geographically, where as NO_2 concentration levels differ widely depending on geographical region.

4 EXAMINING THE RELATIONSHIP BETWEEN AIR POLLUTION, AREA LEVEL DEPRIVATION AND ASTHMA IN CHILDREN IN ENGLAND USING MULTILEVEL MODELLING

4.1 Philip McBride, PhD student, University of Exeter Medical School.

4.2 Looking at the relationship between air pollution, area-level deprivation and asthma in children in England using multi-level modelling.

4.3 Children are especially susceptible to air pollution, leading to disability and deaths.

4.4 Appears to be related to socio-economic factors.

4.5 Social causation theory studies three areas: neomaterial (such as income, poor housing etc.); cultural-behaviour (socioeconomic factors influence on smoking and drinking habits); and psycho-social (dominant and submissive personality types, for instance).

4.6 Data used the Millennium Cohort Study, secure data at the individual level.

4.7 Track $PM_{2.5}$, PM_{10}, NO_2, NO & ozone.

4.8 Results:

4.9 Used logistic regression.

4.10 Social housing appeared to have a correlation with asthma.

4.11 If the mother had asthma, the child was more like to have asthma.

4.12 $PM_{2.5}$ levels were also strongly correlated with asthma prevalence.

4.13 Asthma was studied as there was more data available on this health outcome.

4.14 A question was asked if antibiotic use was accounted for as there is a link between this and asthma.

5 PERSONAL EXPOSURE TO PM2.5 AND ITS ACUTE EFFECTS ON INFLAMMATORY BIOMARKERS AND BLOOD PRESSURE OF LOCAL RESIDENTS IN URBAN AND RURAL BEIJING: RESULTS FROM THE AIRLESS PROJECT

5.1 Dr Yinqun Han, Research Fellow, Faculty of Life Sciences and Medicine, King's College London.

5.2 Dr Li Yan, Research Associate, Faculty of Life Sciences and Medicine, King's College London.

5.3 Ambient air pollution is a 4th leading risk factor of mortality in China.

5.4 Deaths and disease are only the tip of the iceberg in terms of health impacts from air pollution.

5.5 The study looks at a comparison between urban settings, which are primarily influenced by traffic emissions, and rural settings, which are primarily affected biomass cooking in China.

5.6 The study looked at ages 50 – 75.

5.7 Results:

5.8 Seasonal difference between $PM_{2.5}$, with levels being higher in winter vs summer. For the rural setting, the winter concentration levels were drastically above summer emissions.

5.9 Ambient $PM_{2.5}$ was significantly higher in rural environments compared to urban environments.

5.10 Personal exposure levels compared to general ambient levels of $PM_{2.5}$ was lower for both geographical regions.

5.11 FeNO was measured via exhaled breath on participants to study the lag effect from $PM_{2.5}$ exposure. The response appeared to be acute, with FeNO measurements being at its highest < 1 day.

5.12 FeNO exhalations levels were higher in urban settings rather than rural.

6 AIR POLLUTION IS AFFECTING RESPIRATORY PATHOGEN COLONISATION

6.1 Dr Jo Purves, Postdoctoral Research Associate, University of Leicester.

6.2 Studies to assess the impact air pollution has on changes in bacteria.

6.3 The focus of research is on $PM_{2.5}$, which they use a clean source of carbon black as a proxy.

6.4 $PM_{2.5}$ is shown to affect cardiovascular disease, respiratory disease and respiratory infections.

6.5 It directly affects human tissues by increasing inflammation.

6.6 What impacts does air pollution have on bacteria? They look at the bacteria's behaviour, structure and its inter-relationship with the host.

6.7 Study on MRSA and streptococcus pneumonia by looking the change in bacterial growth, behaviour and colonisation.

6.8 One aspect looks at the changes to biofilms that are produced by the bacteria. Bacteria cling to surfaces and release a slimy layer called biofilms. These are complex architectural structures that protect bacteria and also promote host colonisation.

6.9 Exposure to black carbon causes surface protrusions in the biofilm and increases its thickness. This makes it easier to break.

6.10 Does this change the interaction between bacteria and hosts? Yes. When placed in the pre-grown bacteria that have been exposed to carbon black is placed in the lungs, it affects the colonisation rates.

6.11 One mechanism for this altered growth is that the genes of the bacteria are all affected by exposure to carbon black.

6.12 Carbon black exposure to bacteria changes the resistance of that bacteria to antibiotics.

7 SHIPPING-RELATED PARTICULATE MATTER AIR POLLUTION: SOURCE-SPECIFIC EFFECTS ON BRONCHIAL EPITHELIAL CELLS

7.1 Dr Matthew Loxham, BBSRC Future Leader Fellow and NIHR Southampton BRC Senior Research Fellow, Faculty of Medicine, University of Southampton.

7.2 Cruise ships always have their auxiliary engines turned on when they are docked to generate power. Southampton is a big hub for shipping, include industry and cruise ships.

7.3 In UK waters, shipping engine oil is required to have < 0.1% sulphurous content or using engine scrubbers.

7.4 Shipping is responsible for 1.5 million tonnes of PM globally, per annum.

7.5 In the EU, the average exposure from maritime PM exposure is 8% of a person's total PM exposure.

7.6 In shipping fuel, the defining elements in its emissions are Nickel (Ni) and Vanadium (V), which are ultra-fine PM.

7.7 Various monitors were installed around Southampton sites, such as next to scrap metal yards where recycled materials are brought from ships, cruise ship ports.

7.8 V & Ni were greatly elevated in the cruise sites only and not other shipping sites. This is likely because of the auxiliary engines always running.

7.9 V & Ni are particularly interesting because of their cardiovascular toxicity properties.

7.10 Cytokine released (IL6, TNFα, 1Liβ, IL1α and GM-CSF) by humans is all higher when exposed to ultrafine PM such as V and Ni.

7.11 V compounds act as PTP inhibitors.

8 AIR POLLUTION – PAST, PRESENT AND FUTURE

8.1 Dr Gary Fuller, Senior Lecturer in Air Quality Measurement, Environmental Research Group, Faculty of Life Sciences and Medicine, King's College London.

8.2 Profile of air pollution has risen in the media.

8.3 John Evelyn, 1661, was the first record in the UK of someone linking health and air pollution. Wrote a letter to King John suggesting half of the population of London were dying as a result of respiratory diseases.

8.4 Monet, the painter's work showed air pollution in London, such as around Waterloo Bridge and Southbank. John Thorne has done some work to analyse these paintings.

8.5 Historical data on air quality is virtually non-existent. However bird specimens in museums have been used to track 135 years of atmospheric black carbon. This has been used in climate modelling.

8.6 Whipple (1929) study electro-potential of the atmosphere and its relationship to pollution, noticing a diurnal and seasonal variation. Harrison (2009) has assessed some of this historical research.

8.7 In 1912, the world's first national air quality network was established to deliver comparable measurements from place-to-place and month-to-month.

8.8 John Owens was the first to produce standard instruments for measuring air pollution in 1926, such as the stoneware deposit gauge. His instrument for measuring British Black Smoke is still used today, which exposes filters to the air and sucks air through the apparatus. The filter colours are then compared to a chart to assess air quality.

8.9 London's 1952 smog disaster was the first time in modern politics health, and air pollution was linked. It is estimated 12,000 people died that summer in London as a result of air pollution.

8.10 It is estimated between 29,000 and 50,000 premature deaths occur in the UK as a result of air pollution.

8.11 The initial Clean Air Act tackled smoke but not SO_2, which soared and eventually led to acid rain.

8.12 The 1970s focussed on traffic as the main source of pollution, and eventually, attention fell on biomass burning, contributing to significant levels of $PM_{2.5}$.

8.13 In 1996 PM_{10} went above 100µg/m^3. However, John Steadman said records only began in 1992, and it is likely exposure went above this many times before. This rise occurred in Spring. Every year Spring is when levels are at its highest.

8.14 Air pollution is global.

8.15 There is a need for political leadership. China has reduced $PM_{2.5}$ by 30% in four years.

8.16 The launch of the Clean Air Strategy 2019 had two secretaries of state present – a promising sign of the ever increasing importance.

8.17 There are many campaigns for closure of roads around schools.

8.18 Diesel sales are falling in the UK and globally.

8.19 Air pollution and climate change need tackling together. Reducing energy demand will also reduce air pollution.

8.20 We need to think about how we heat our homes, end petrol & diesel vehicles, think about public transport and tackling this issue must be a global effort.

9 A NEW APPROACH TO QUANTIFY NON-ROAD MOBILE MACHINERY EMISSIONS FOR LONDON

9.1 Carl Desouza, PhD student, Department of Analytical, Environmental and Forensic Sciences, King's College London.

9.2 Non-road mobile machinery (NRMM) is essentially a construction plant such as excavators, generators, telehandlers etc.

9.3 For modelling the emissions from NRMM, a top-down approach is normally used. The London atmospheric emission inventory (LAEI) and national atmospheric emission inventory (NAEI) is used as a data source. This shows that construction's contribution to PM and NO_x is 15% and 7%, respectively

9.4 Carl advocated a 'bottom-up approach.'

9.5 First, real-world emissions of the NRMMs are measured used PEMs (Portable Emissions Measurement). This measures the emissions from tail pipes from the plant. Telehandlers were the biggest source of pollution.

9.6 Next, they look at the geographical data of construction sites in London and what plant is being used. They get this information from the London NRMM register, which tracks all the plant being used on construction and their length of time. This tells them the type of machines being used.

9.7 They also take their own activity data of plant by using engine telematics and also direct measurements via data loggers.

9.8 They aggregate all this data and plot on a map to show how much emissions are being emitted by construction NRMMs.

9.9 They can then test different scenarios. One example was if they accelerated the uptake of stage IV equipment from Stage III level emissions. If we did this for excavators alone, its contribution to construction NO_x emission levels would fall from 30% to 2%.

10 ACCOUNTING FOR ACTIVITY PATTERNS IN EXPOSURE ASSESSMENTS: WHY AND HOW

10.1 Dr Audrey de Nazelle, Senior Lecturer, Centre for Environmental Policy, Imperial College London.

10.2 New opportunities have opened up for tracking activity patterns and air pollution data thanks to technology.

10.3 Their research looks at three different methods:

1. Cell phone data usage from network providers (GPS coordinates)
2. Smartphone data from individual users (using GPS and activity tracker app)
3. Personal monitoring on individuals (carbon black monitor and activity wearable)

10.4 The first method:

10.5 Overlays network providers information with air pollution maps for NO_2.

10.6 This allowed data on seeing where the individuals spent their time, rather than the general approach of using the home address only. This allows taking into account exposures in work, travel and at home.

10.7 The second method:

10.8 Analyses cell phone data using geolocation and physical activity via the CALFIT app.

10.9 This allowed estimating exposures based on location and their inhaled pollution exposure.

10.10 This showed that 51% of the time was spent at home, 27% of time spent at work, 11% spent on transport and 16 % in other.

10.11 Transport related to 26% of the inhaled intake of NO_2 despite such short time spent in transit and the home was only 37% inhalation.

10.12 Public transport showed the highest inhalation of $PM_{2.5}$ of 36% of the total and 22% was the lowest in private travel.

10.13 The third method showed similar results, with cycling showing the highest inhalation of carbon black with 13.3% and vehicle travel being the lowest out of travel at 2.5%.

11 INTERVENTIONS TO REDUCE PROFESSIONAL DRIVERS EXPOSURE TO BLACK CARBON IN LONDON; THE DIESEL EXPOSURE MITIGATION STUDY

11.1 Shannon Lim, Research Assistant, Department of Analytical, Environmental and Forensic Sciences, King's College London.

11.2 Diesel Exposure Mitigation Study.

11.3 Diesel engine exhaust emissions classed as group 1 carcinogen by IARC 2012.

11.4 The study monitored 150 professional drivers using a black carbon monitor (microaethalometer MA300/350) as a proxy for air quality, logging every 10 seconds.

11.5 The order of exposure from highest to lowest is taxi drivers, couriers, construction waste, waste removal, construction, utility services, emergency services and heavy freight.

11.6 On average, despite only spending 18% of their time driving, it resulted in 40% of their exposure to carbon black.

11.7 Pollution spikes at Hyde Park Corner and Earl's Court.

11.8 Drivers with windows down increased their exposure by 1.6x compared to driving with window's closed.

11.9 Recirculatory ventilation has no effect on exposure.

11.10 Tunnels caused large spikes, demonstrating they need to be better ventilated.

11.11 They also assessed diesel taxis vs hybrid diesel/electric taxis. Emissions were a lot lower for the latter. However they were also newer cars so they suggest airtightness would be greatly improved.

12 THE LONDON UNDERGROUND AND PARTICLE AIR POLLUTION: CURRENT SITUATION AND MOVING FORWARD

12.1 Dr Sarah Robertson, Principal Environmental Public Health Scientist, Environmental Hazards and Emergencies, Public Health England.

12.2 COMEAP review: Committee of the medical effects of air pollutants

12.3 Last reviewed in 1998, based on the evidence at the time

12.4 On the underground, mean $PM_{2.5}$ is up to 4 x than ambient London concentrations and 3x higher than the roadside environment in London.

12.5 The approach reviewed multiple studies: epidemiological, exposures, experimental etc.

12.6 There are working papers available on the COMEAP website.

12.7 There are only 8 epidemiological studies on exposure to subway environments, none of which are in London.

12.8 In vitro cell systems have been more widely used to assess health impacts.

12.9 Toxicological studies have yielded inconsistent results.

12.10 2015 COMEAP could not conclude the most significant exposure from varying sources of PM on health.

12.11 The age of the line and depth of the station all play a role in determining the concentration of PM. However, ventilation rates play a crucial role.

12.12 COMEAP could not make any conclusions due to the lack of evidence but could not rule out any health risks either as a result of underground air pollution.

12.13 TFL are not monitoring $PM_{2.5}$ and PM_{10}, which will be available for research.

12.14 Metal monitoring in underground stations has also been carried out and will be available on TFL's website in May 2019.