In collaboration with:

ETA ENJOY THE AIR

Sandwell Metropolitan Borough Council

EARTHSENSE

GEOVATION from Ordnance Survey

HEALTH LUMEN

Modelling the epidemiological and economic impacts of air pollution reduction in the English metropolitan borough of Sandwell

Timothy Coker, Richard Hargreaves, Anna Stewart, Jonathan Freeman, Jade Shermer, David Green, Elizabeth Stephens, Lizzie Atkin, Errol Kruger, Kate Barnard, Laura Webber, Lise Retat

Tuesday 9th January 2024

Funded by:

UKRI Innovate UK

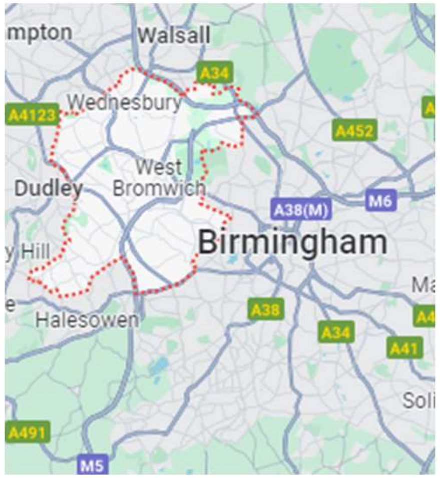
Background

- Air pollution is a major public health concern with a high burden of disease.
- Air pollution is a driver of various non-communicable diseases (NCDs), including, but not limited to: **asthma, stroke, coronary heart disease and lung cancer**.
- Understanding the extent and magnitude of air pollution's impact on long-term health is important for future National Health Service (NHS) budget allocation, priority setting, and policy planning.
- The project demonstrated a proof of concept in **Sandwell**, **UK** enabling local authorities to:
  - **plan community priorities** by calculating short- and long-term health benefits of Disease Prevention;
  - and to digitally 'nudge' **behaviour change** at locations where air emissions present significant health risk

Sandwell

- Sandwell is a metropolitan borough in the West Midlands, bordering Birmingham, one of the UK's largest cities.

- It sees significant traffic via the M5, a major road which connects Bristol (in the South) to the West Midlands.



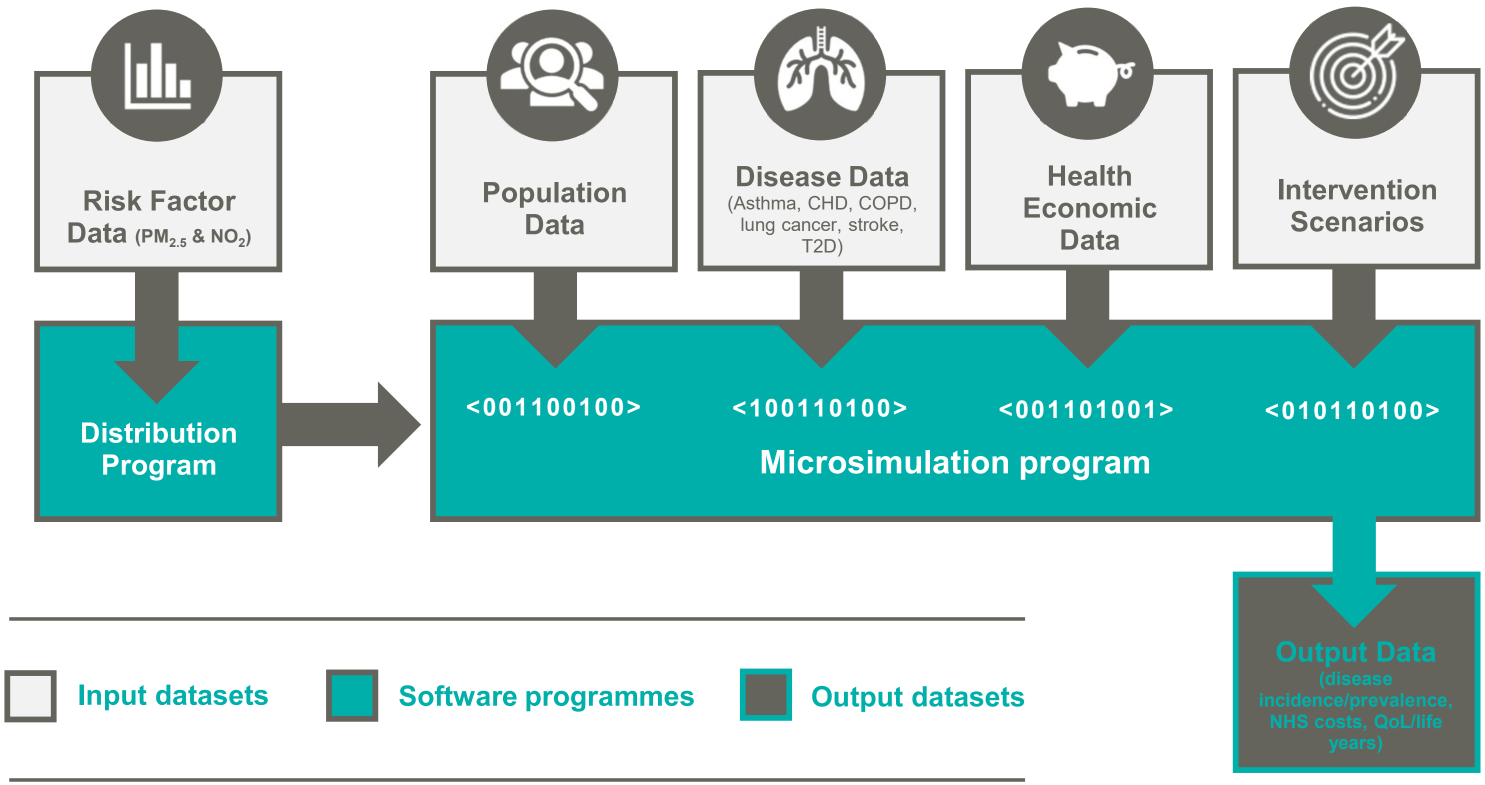
Images: Google Maps
Sandwell.gov.uk

Microsimulation model aims

- The specific aims of this component of the project, using a validated microsimulation model [1], are as follows:
  - Generate a model of the health and economic consequences of air pollution specific to Sandwell Metropolitan borough (utilising local population and pollution sensor data).
  - Use the model to test the health and economic benefits of a hypothetical air pollution reduction scenario, driven by a combination of policy and behavioural change.
    - Impacts will be assessed over a 10-year timespan (2023-2033).
    - The hypothetical scenario assumes a gradual drop in air pollution exposure across the population over the span of 5 years (2023-27 inclusive).

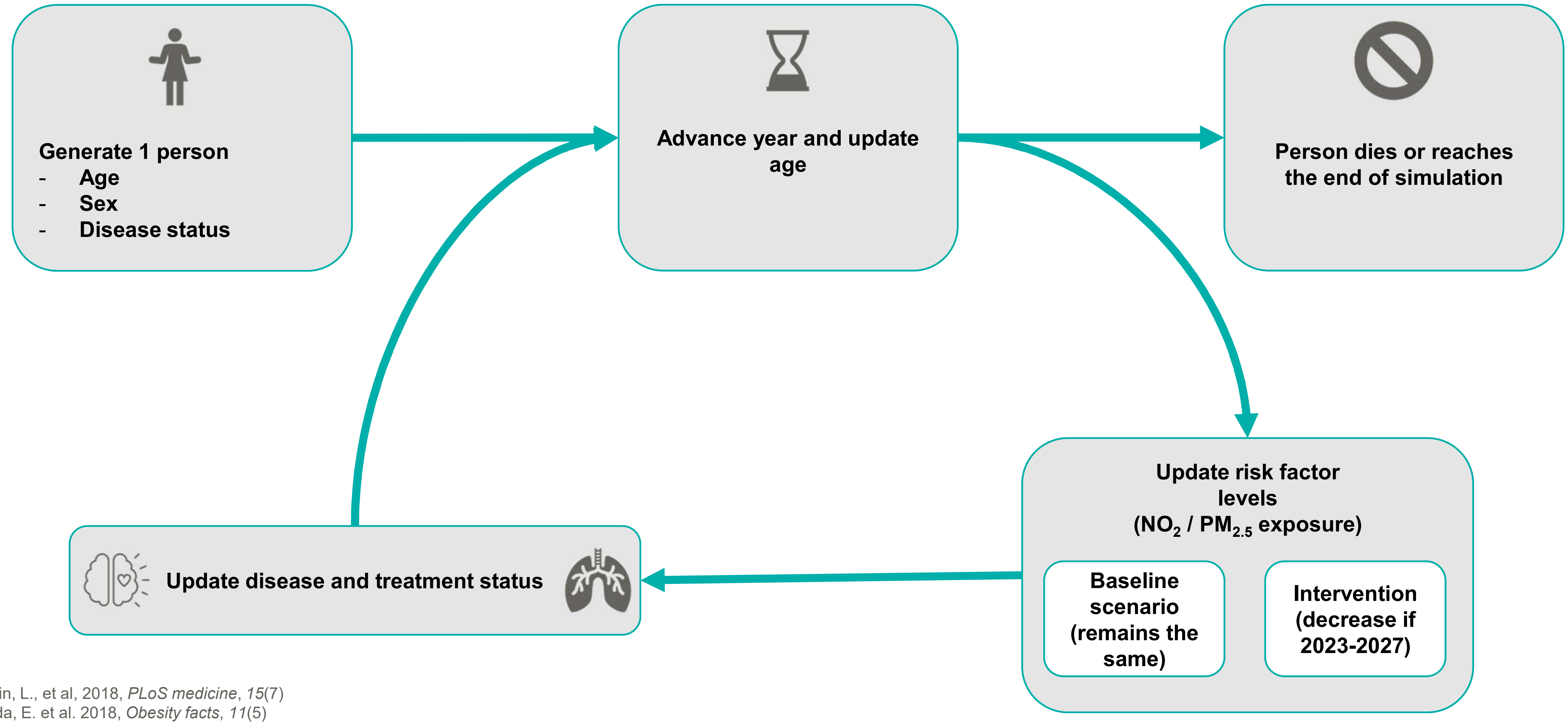
[1] Pimpin L, Retat L, Fecht D, de Preux L, Sassi F, Gulliver J, Belloni A, Ferguson B, Corbould E, Jaccard A, Webber L. Estimating the costs of air pollution to the National Health Service and social care: An assessment and forecast up to 2035. PLoS medicine. 2018 Jul 10;15(7):e1002602.

Overview of the microsimulation and its components



[1]: Pimpin, L., et al, 2018, *PLoS medicine*, *15*(7)
[2]: Pineda, E. et al. 2018, *Obesity facts*, *11*(5)
[3]: HL publications can be found here: https://www.healthlumen.com/track-record/

Epidemiological module of the HealthLumen microsimulation [1,2,3] for one person



[1]: Pimpin, L., et al, 2018, *PLoS medicine*, *15*(7)
[2]: Pineda, E. et al. 2018, *Obesity facts*, *11*(5)
[3]: HL publications can be found here: https://www.healthlumen.com/track-record/

Methods: risk factors ($PM_{2.5}$ and NO_2)

- Risk factor data ($PM_{2.5}$ and NO_2) were collected from sensor data from across Sandwell (supplied by Earthsense).
- For this study, we use data from 2019.
  - 2020 onwards was excluded to discount any changes in air pollution due to covid-19 and associated policies. We assume that current pollutant exposure matches pre-pandemic levels.
  - In our baseline scenario, we conservatively assume that air pollution / exposure remains static over the course of the microsimulation (2023-2033).
- $PM_{2.5}$ / NO_2 sensor data were mapped onto individual-level exposure based on the following assumptions [1]:
  - We assume that $PM_{2.5}$ / NO_2 exposure data aligns with residence (i.e. do not account for transport within or in/out of Sandwell).
  - Age/sex distribution of $PM_{2.5}$ / NO_2 exposure was inferred by mapping ward-level $PM_{2.5}$ / NO_2 levels (mean and SD) to census data.
  - We assume a normal distribution of $PM_{2.5}$ / NO_2 exposure within age/sex categories.

Risk Factor Data (PM2.5 & NO2)

[1] : Pimpin, L., et al, 2018, *PLoS medicine*, *15*(7)

Modelled diseases

- The following diseases were modelled based on the evidence supporting their link to air pollution ($PM_{2.5}$ and NO_2):

$PM_{2.5}$	NO_2 [6]
- Asthma (childhood) [1, 2, 3] - CHD [1, 2, 3] - COPD [4] - Lung cancer [5] - Stroke [1, 2, 3] - Type 2 diabetes [1, 2]	- Asthma (childhood and adult) [1, 2, 7] - Lung cancer [7] - Type 2 diabetes [1, 2, 7]

[1] World Health Organization. Review of evidence on health aspects of air pollution–REVIHAAP Project. World Health Organization, Copenhagen, Denmark. 2013.
[2] Royal College of Physicians. Every breath we take: The lifelong impact of air pollution 2016. Available from: https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution.
[3] US Environmental Protection Agency. Integrated Science Assessment for Particulate Matter (Final Report, Dec 2009) 2009. Available from: https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=216546.
[4] Committee On The Medical Effects Of Air Pollutants (COMEAP). COMEAP: long-term exposure to air pollution and chronic bronchitis 2016. Available from: https://www.gov.uk/government/publications/comeap-long-term-exposure-to-air-pollution-and-chronic-bronchitis.
[5] International Agency for Research on Cancer. IARC monograph on the evaluation of carcinogenic risks to humans 2016 [cited Outdoor air pollution]. Available from: http://monographs.iarc.fr/ENG/Monographs/vol109/mono109.pdf.
[6] Committee on the medical effects of air pollutant (COMEAP). Statement on the evidence for the effects of nitrogen dioxide on health 2015. Available from: https://www.gov.uk/government/publications/nitrogen-dioxide-health-effects-of-exposure.
[7] US Environmental Protection Agency. Integrated science assessment for oxides of nitrogen – health criteria (final report 2016 EPA/600/R-15/068). 2016.

Disease Data
(Asthma, CHD, COPD, lung cancer, stroke, T2D)

Assumptions: costs and quality of life

- Total costs were calculated by applying the annual cost per case to all prevalent cases of each disease modelled. I.e.:
    - *Annual cost of disease = Annual cost per case * disease prevalence*
- Quality of life (QoL) was estimated using a multiplicative method:
    - By default, QoL is assumed to be 1.
    - If an individual has a disease, their QoL is multiplied by that disease's utility weight (repeat for all diseases).
    - E.g. if a person has both asthma and CHD, their QoL would be 1 * 0.722 * 0.61 = 0.44042
    - If a person dies, their QoL becomes 0.
    - Quality-adjusted life years (QALYs) are the sum of all individuals' QoL scores across one or more years.

Health Economic Data

Intervention assumptions

- Intervention is based on evidence from:

Font & Fuller (2016) Did policies to abate atmospheric emissions from traffic have a positive effect in London? *Eviron. Pollution.*

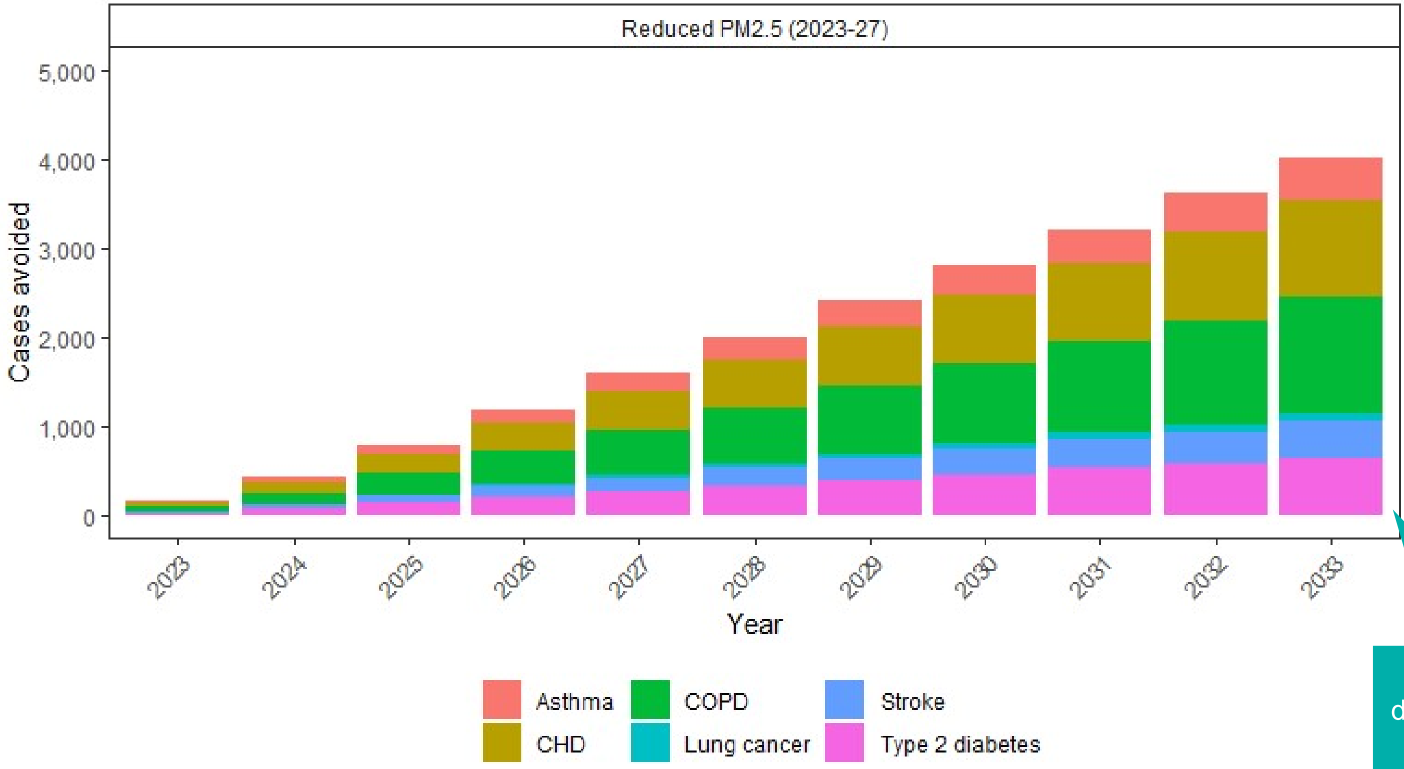
- This study evaluated the impact of environmental policies on concentrations of pollutants (NO2, PM2.5 etc.) in London.
  - Compares two time points: 2005-9 and 2010-4.
  - Environmental policies include investment into catalytic diesel particulate filters and hybrid / low-emission buses, implementation of a Low Emission Zone, and other local schemes.
- The paper reports % drops for several clusters of sites within London.
  - For Sandwell, we selected sites showing similar levels of road traffic to Sandwell.

Selected intervention parameters:

NO2
3.41% annual decrease
2023-27 (inclusive)

PM2.5
20.83% annual decrease
2023-27 (inclusive)

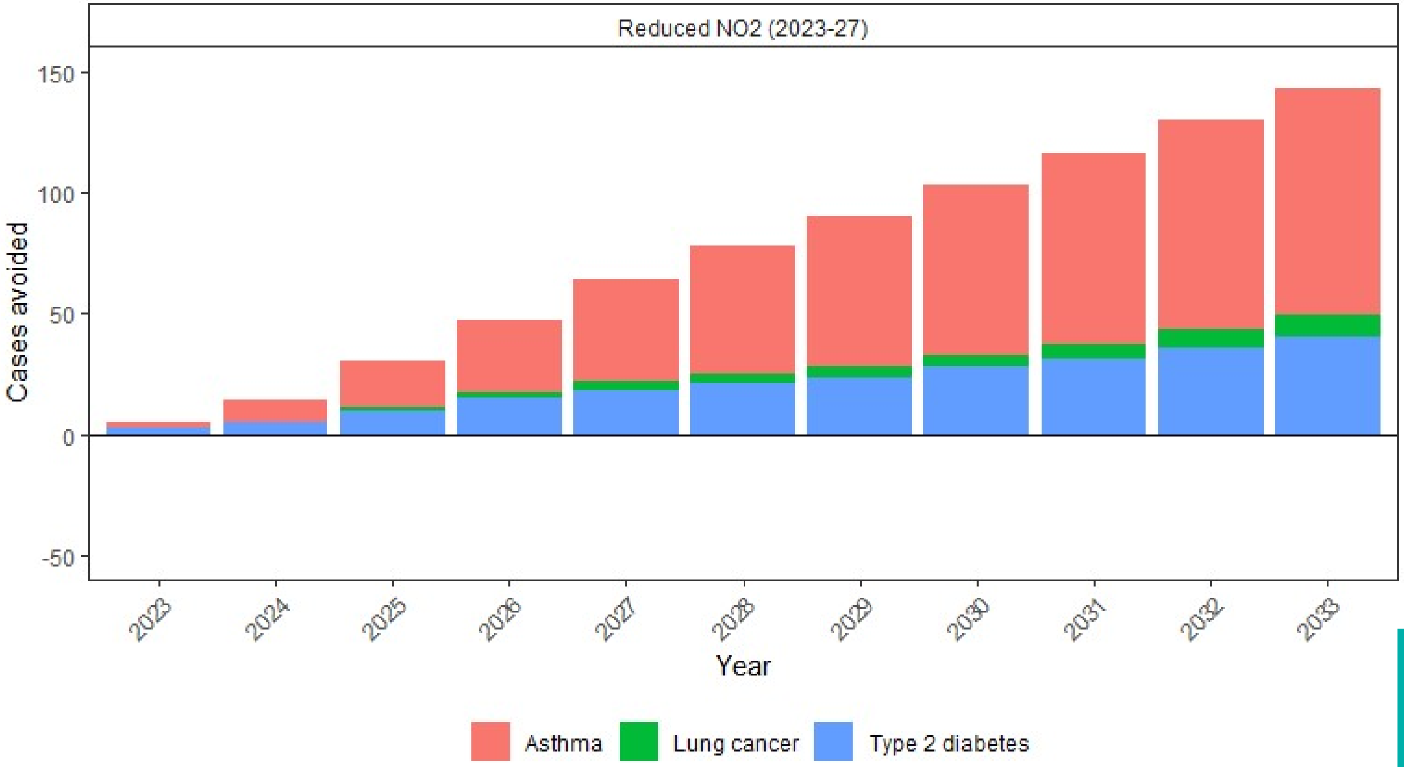
PM2.5: The intervention is predicted to result in 4016 fewer new cases of disease by 2033



Disease	Incident cases avoided, 2023-33
Asthma	470
CHD	1094
COPD	1295
Lung cancer	94
Stroke	406
Type 2 diabetes	657

COPD, CHD and type 2 diabetes comprise a large portion of disease avoided.

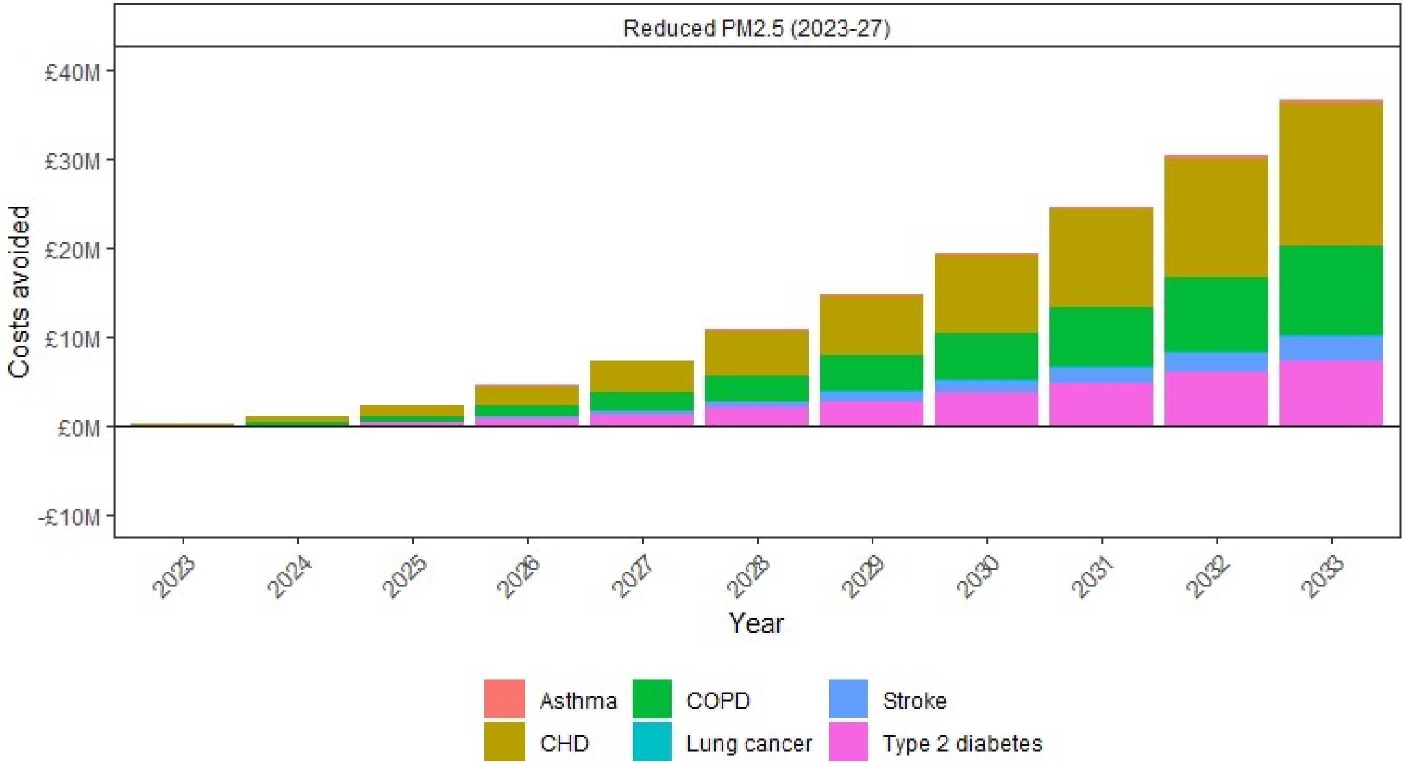
NO2: The intervention is predicted to result in 143 fewer new cases of disease by 2033



Disease	Incident cases avoided, 2023-33
Asthma	94
Lung cancer	9
Type 2 diabetes	40

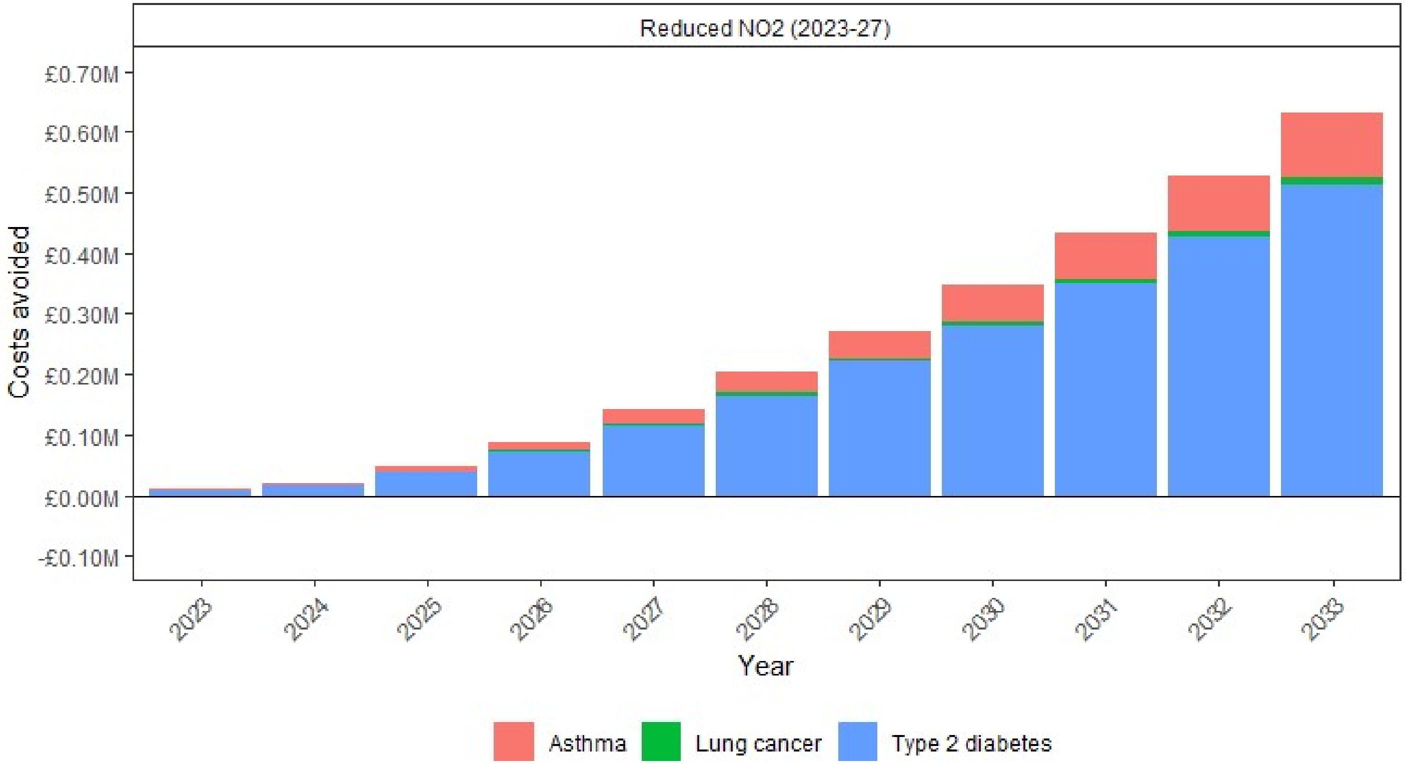
Asthma and type 2 diabetes comprise a large portion of disease avoided.

PM2.5: By 2033, the modelled intervention is projected to save the NHS around £36.6M in disease costs



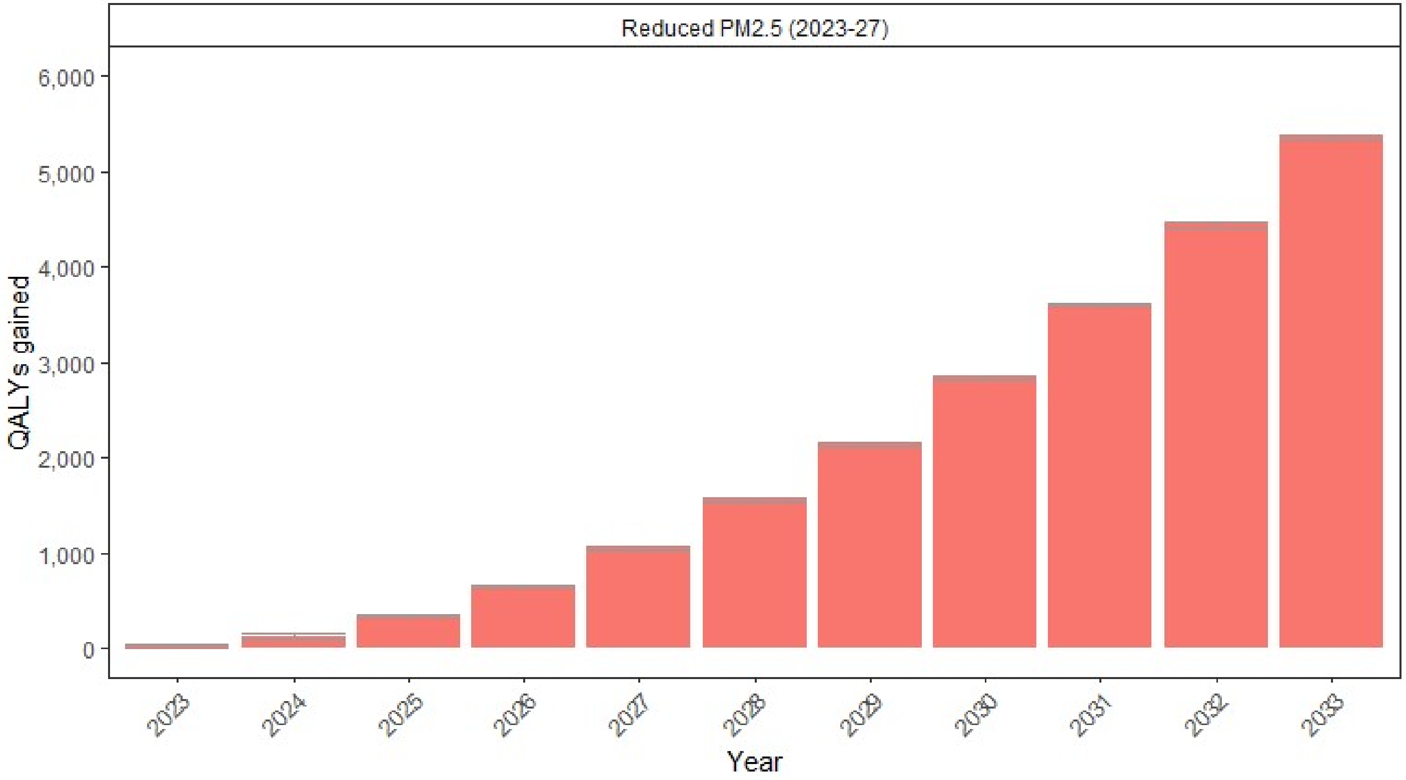
CHD and COPD comprise the majority of disease costs avoided

NO2: By 2033, the modelled intervention is projected to save the NHS around £0.6M in disease costs

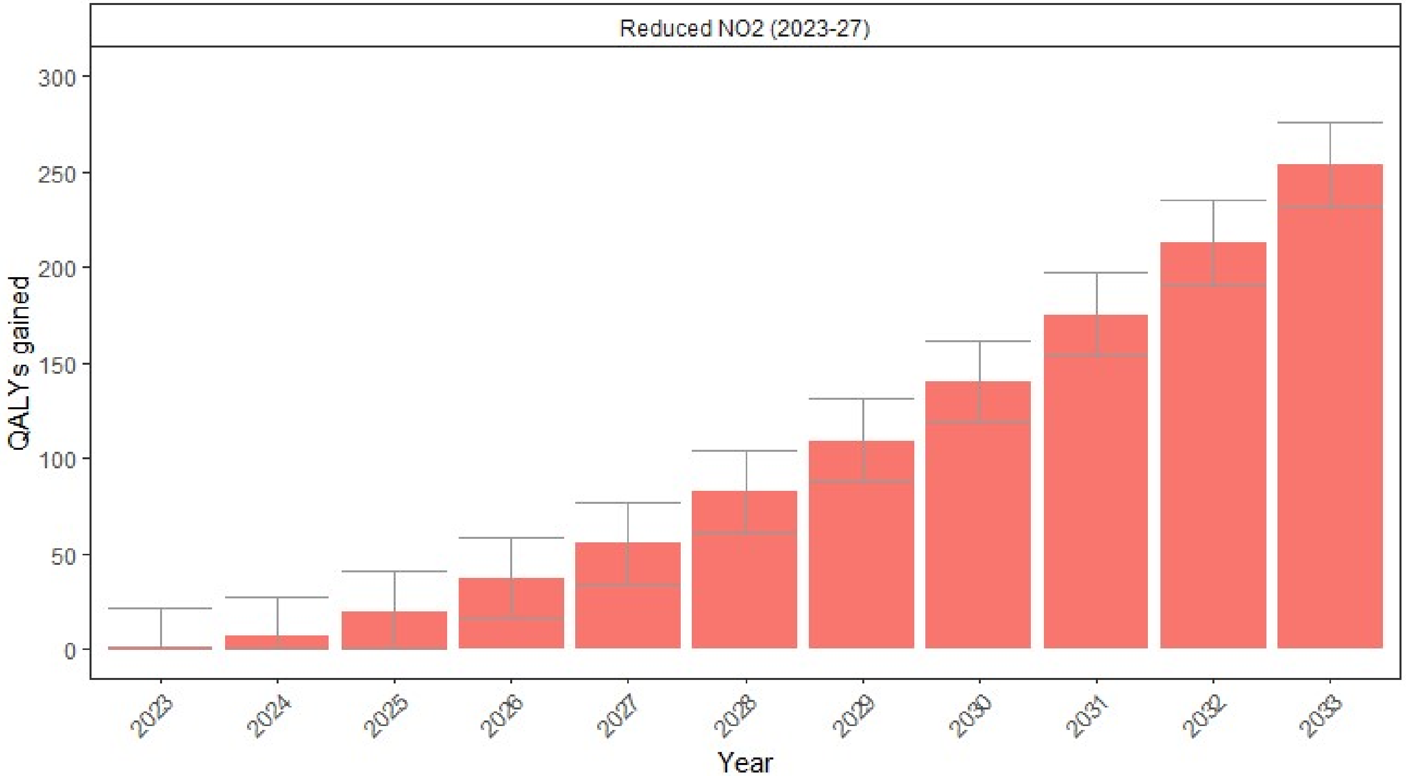


Type 2 diabetes comprises the majority of disease costs avoided

PM2.5: By 2033, the intervention is predicted to result in 5,351 additional quality-adjusted life years (QALYs)



NO2: By 2033, the intervention is predicted to result in 253 additional quality-adjusted life years (QALYs)



Strengths and limitations

Strengths

- The **microsimulation is a robust tool** for modelling population-level interventions in detail because it models every individual many years into the future. Individuals are randomly generated with relevant characteristics (age, sex, exposure) to produce detailed intervention outcomes.

- Inputs are based on **high-quality data**, including robust literature searches, local demographic data and high-resolution air quality monitoring data.

- Given the right data, this **approach can be applied to other UK regions**, or regions in other countries.

Limitations

- Microsimulation doesn't account for **spatial and temporal variation in pollutants**. Microsimulation models exposure distributions by age, sex and year. Does not account for daily variations in pollutants, nor variation in pollutant at e.g. road level.

- Relies on **real-world evidence from another UK region**. An intervention applied in Sandwell may not be wholly reflective of one applied in London. Interventions should be tailored to local circumstances.

- Challenges **projecting air pollution into the future**, e.g. natural variation in PM2.5 and unexpected factors e.g. COVID-19.

- Other factors such as **socio-economic status** outside of project scope. Deprived sub-populations are more susceptible to the negative health effects of air pollution and at the same time are more likely to be exposed to higher air pollution levels

Main key messages

Reduced air pollution exposure in Sandwell due to policy and behavioural change has the potential to prevent thousands of cases of diseases, save millions of pounds worth of costs to the local healthcare system, and improve the quality of life of the local population.

For example, as a result of a **policy/behaviour change** scenario in which we assume a decline in $PM_{2.5}$/NO_2 over five years [2023-27 inclusive], we showed that the cumulative annual reductions of $PM_{2.5}$ and NO_2 exposures by 20.83% and 3.41% (2023-27) respectively, would result in :

- Over **4,100** fewer new (cumulative incident) cases of diseases
- Over **5,500** additional **quality-adjusted life years** (QALYs)
- **£37M** healthcare costs avoided due to reduction in the disease burden
- Over **800** additional years of working life

THANK YOU