Energy efficiency interventions and health: Quantifying the impact of indoor air pollution on childhood asthma in UK schools

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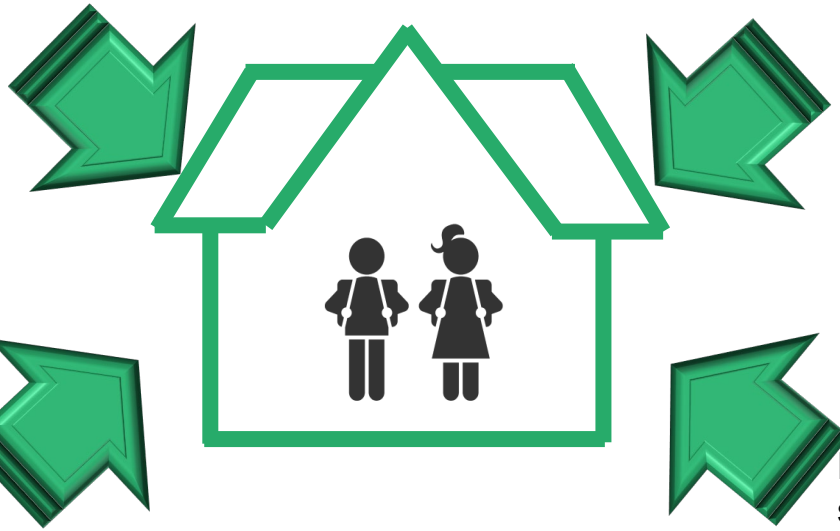
Background

Schoolchildren spend almost 30% of their life at school, around 70% of which inside a classroom



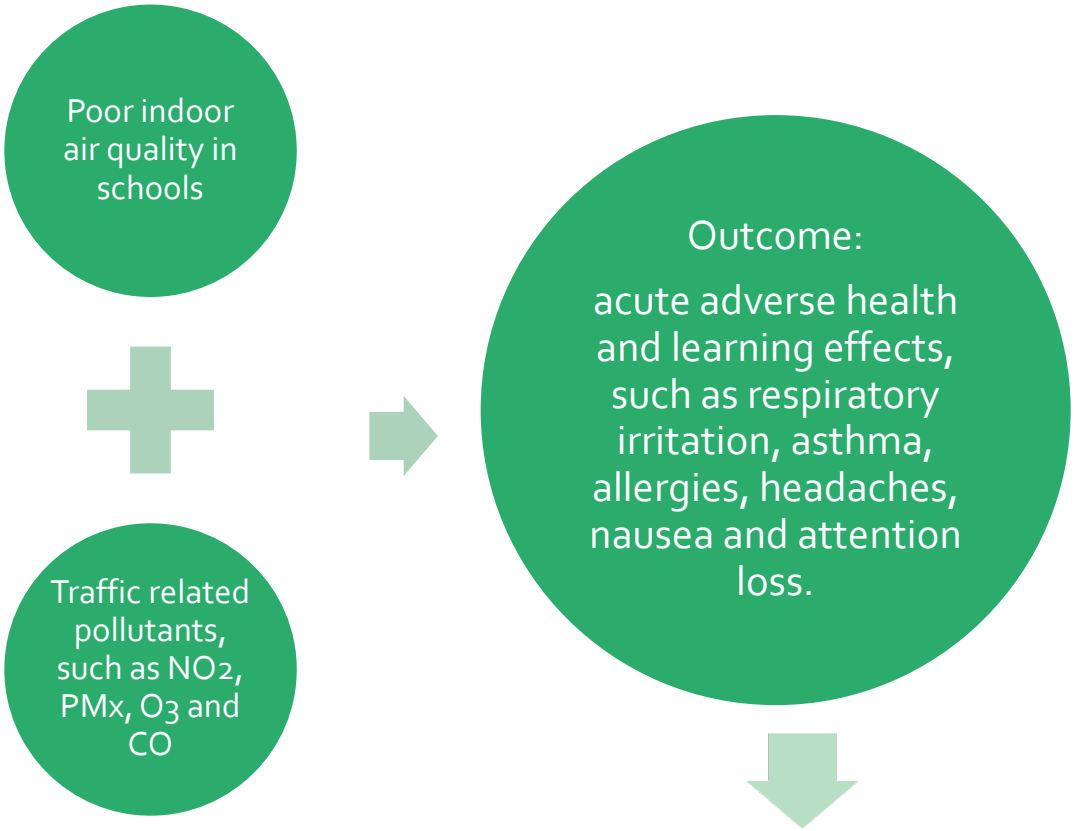
Substantial impacts on the learning performance and health of schoolchildren

Indoor air quality and thermal comfort

Energy efficiency of school buildings

Health impacts of indoor environment quality (IEQ) on school children

Objective

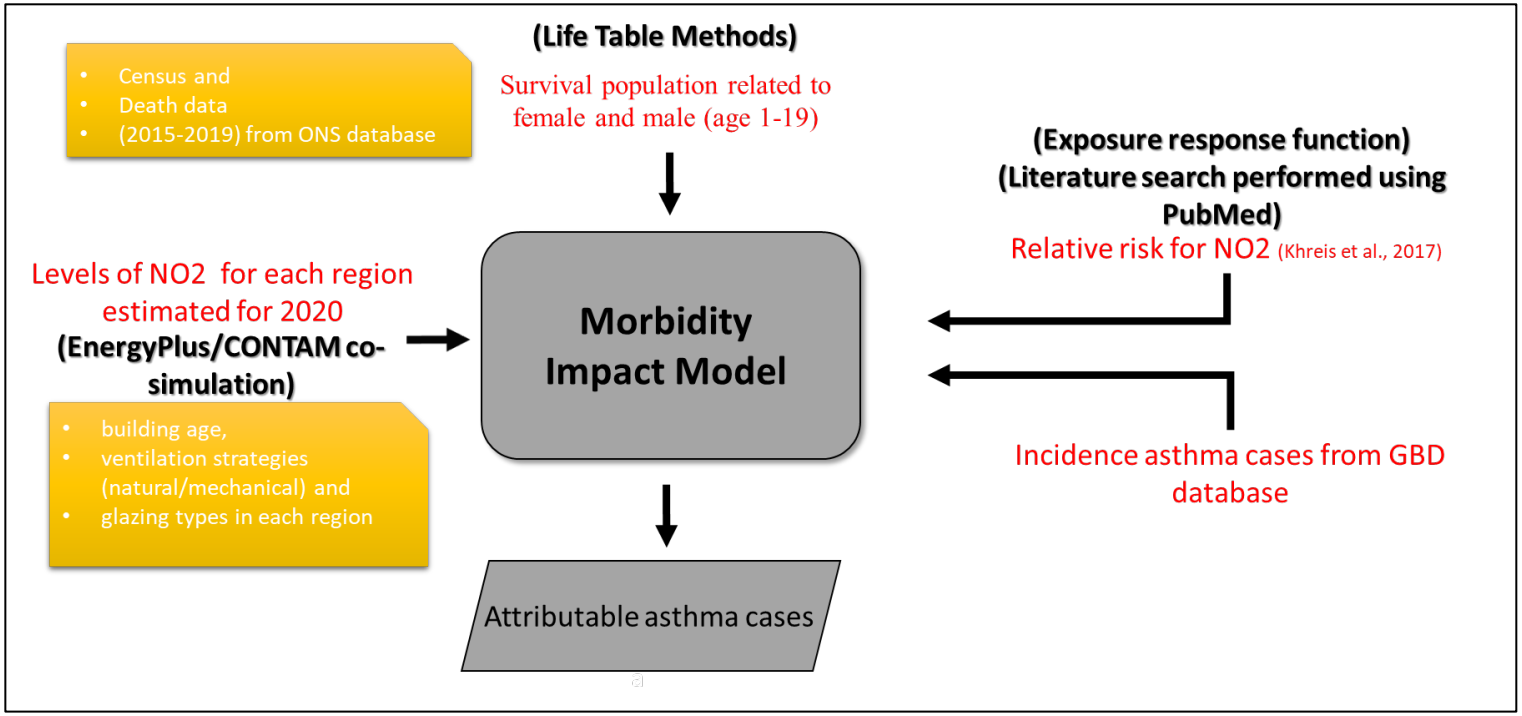


Asthma affects many of the children's life qualities.

Aim of this study:

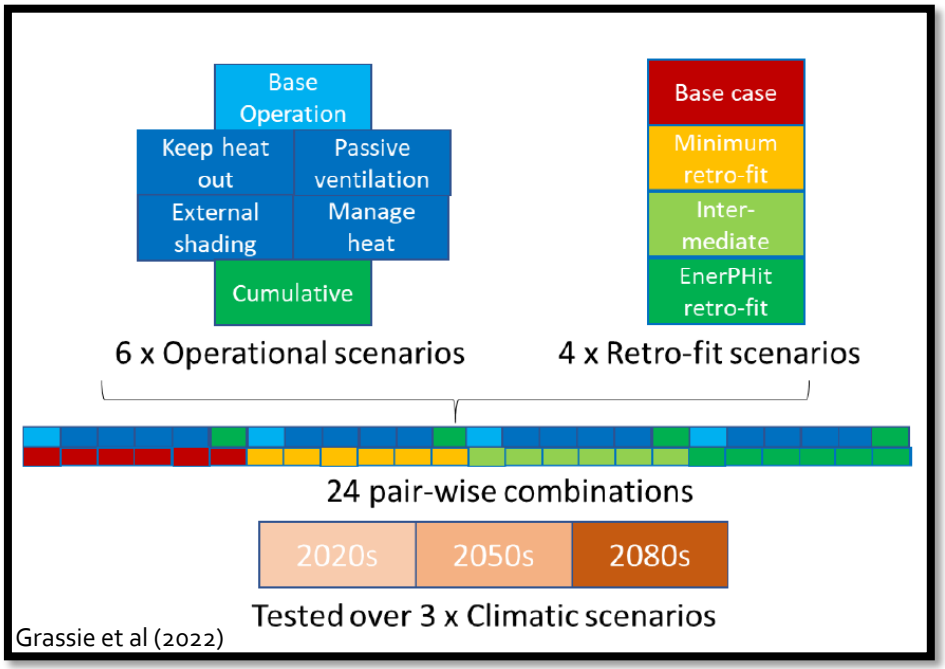
- ✓ Quantification of the impact of indoor air pollution in UK schools on **childhood asthma.**
- ✓ Assessment of impacts of **different mitigation strategies** on **asthma incidence in the future.**

Methods



Health Impact Assessment: Conceptual Framework

INPUT - NO2 concentration and mitigation strategies



Dynamic building performance modelling

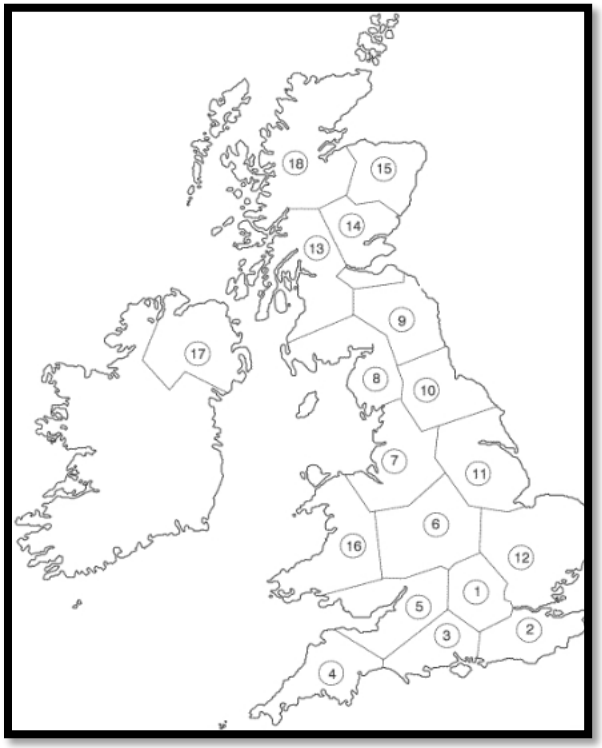
Outputs: CO_2 / $PM_{2.5}$ / NO_2 / Energy / Temperature

Location

❖ Regions

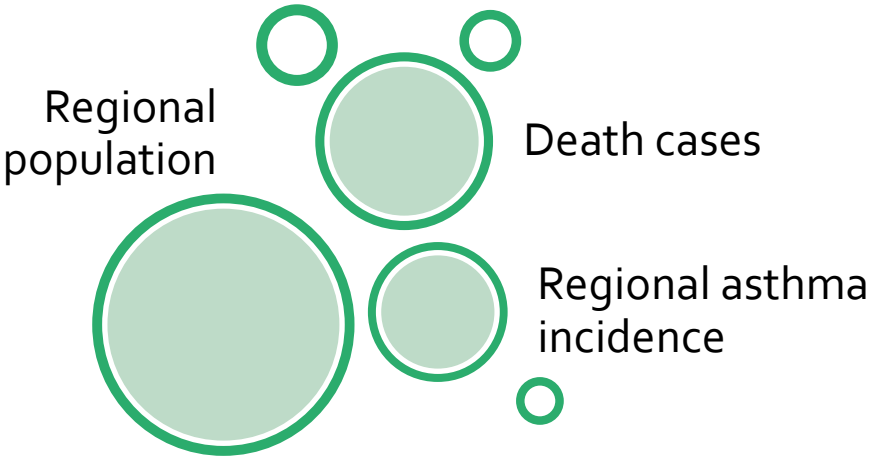
- The impact of nitrogen dioxide (NO_2) exposures in schools on the burden of childhood asthma for **13 climate regions of England and Wales.**

1. Thames Valley	4. South Western	7. West Pennines	10. North Eastern	13. West Scotland	16. Wales
2. South Eastern	5. Severn Valley	8. North Western	11. East Pennines	14. East Scotland	17. Northern Ireland
3. Southern	6. Midlands	9. Borders	12. East Anglia	15. North East Scotland	18. North West Scotland



INPUT

- **Population and Morbidity data**
  - Regional asthma incidence →Global Burden of Disease (GBD) study
  - Census and Death data →the Office for National Statistics (ONS)
  - Age group: 5-16 (primary and secondary school age)
  - Cohort study → follow-up for 11 years :2020 (Age 5)-2031 (Age 16)



Attributable Asthma Cases

- **Exposure-response function**
  - the relative risk of 0.8 per 10 ppb increase in ambient NO2(Oftedal et al. 2009)
- **Estimation of population attributable fraction and attributable number of cases (Khreis etal 2018)**

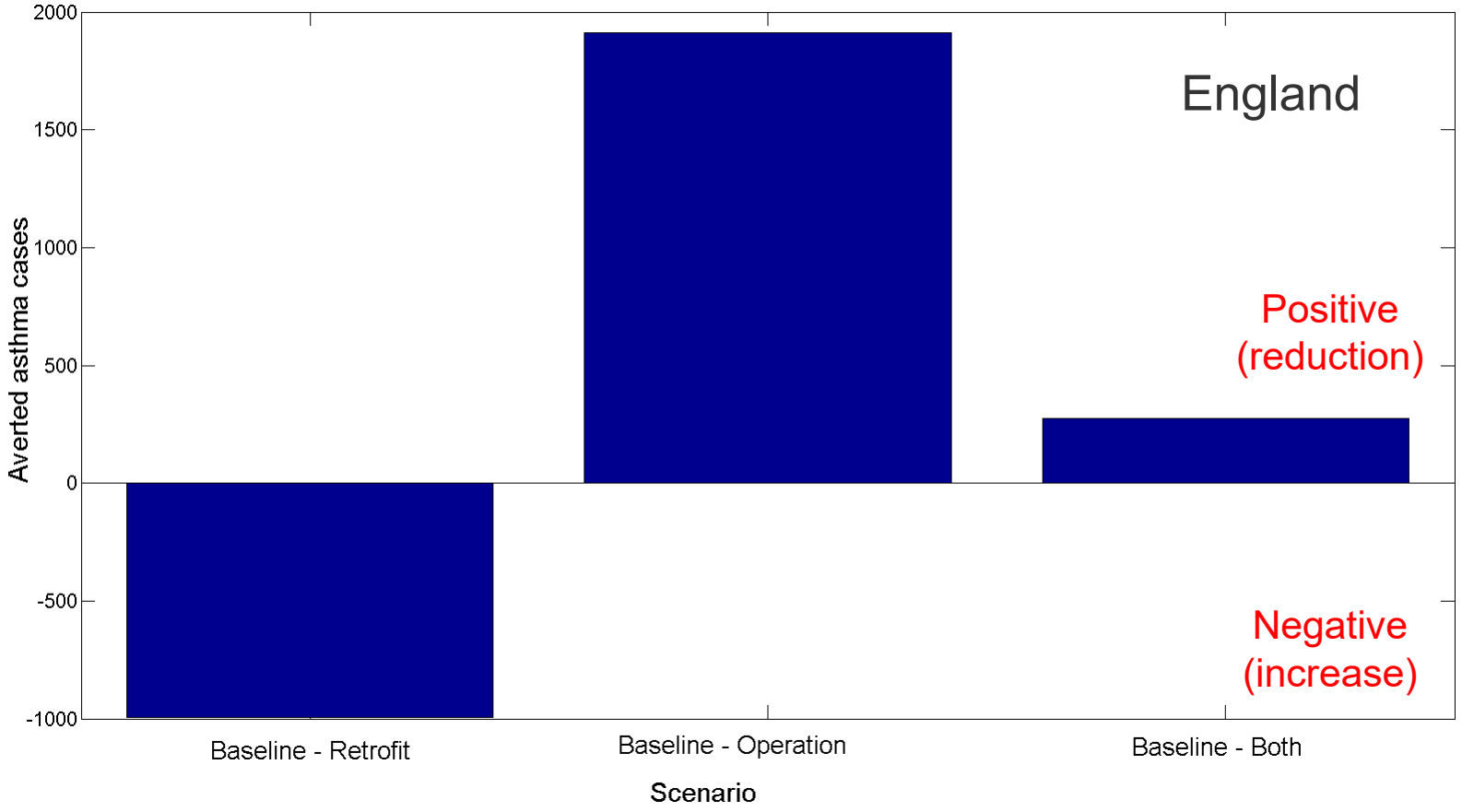
Steps	Equations
1	$RR_{exposure_{difference}} = e^{\left(\left(\frac{LnRR}{E_{RRunit}}\right)\times E_{exposure\_difference}\right)}$
2	$PAF = \frac{\sum_{i=1}^{n} P(RR_{exposure_{difference}} - 1)}{\sum_{i=1}^{n} P(RR_{exposure_{difference}} - 1) + 1}$
3	Expected asthma cases due to all causes = childhood population * baseline childhood asthma incidence rate
4	Attributable number of asthma cases=PAF*expected asthma cases due to all causes

Comparison of **3 strategies** with Baseline (current situation):

Scenarios	Retrofit Strategy	Operational Measure
	(improvements in heat transfer and building energy efficiency)	(Classroom operational changes: mitigating against overheating and indoor air quality)
Baseline	No changes to underlying base models(Schwartz et al., 2021)	No additional measures
1. Retrofit	Criteria required for EnerPHit retro-fit (Institute, 2016)(*)	No additional measures
2. Operation	No changes to underlying base models(Schwartz et al., 2021)	All operational measures including Keep heat out– Wall albedo, blinds when sunny Add external shading Manage heat– shut windows when hot Passive ventilation- night ventilation (**)
3. Both (Retrofit and Operation)	Criteria required for EnerPHit retro-fit (Institute, 2016)(*)	All operational measures including Keep heat out– Wall albedo, blinds when sunny Add external shading Manage heat– shut windows when hot Passive ventilation- night ventilation (**)

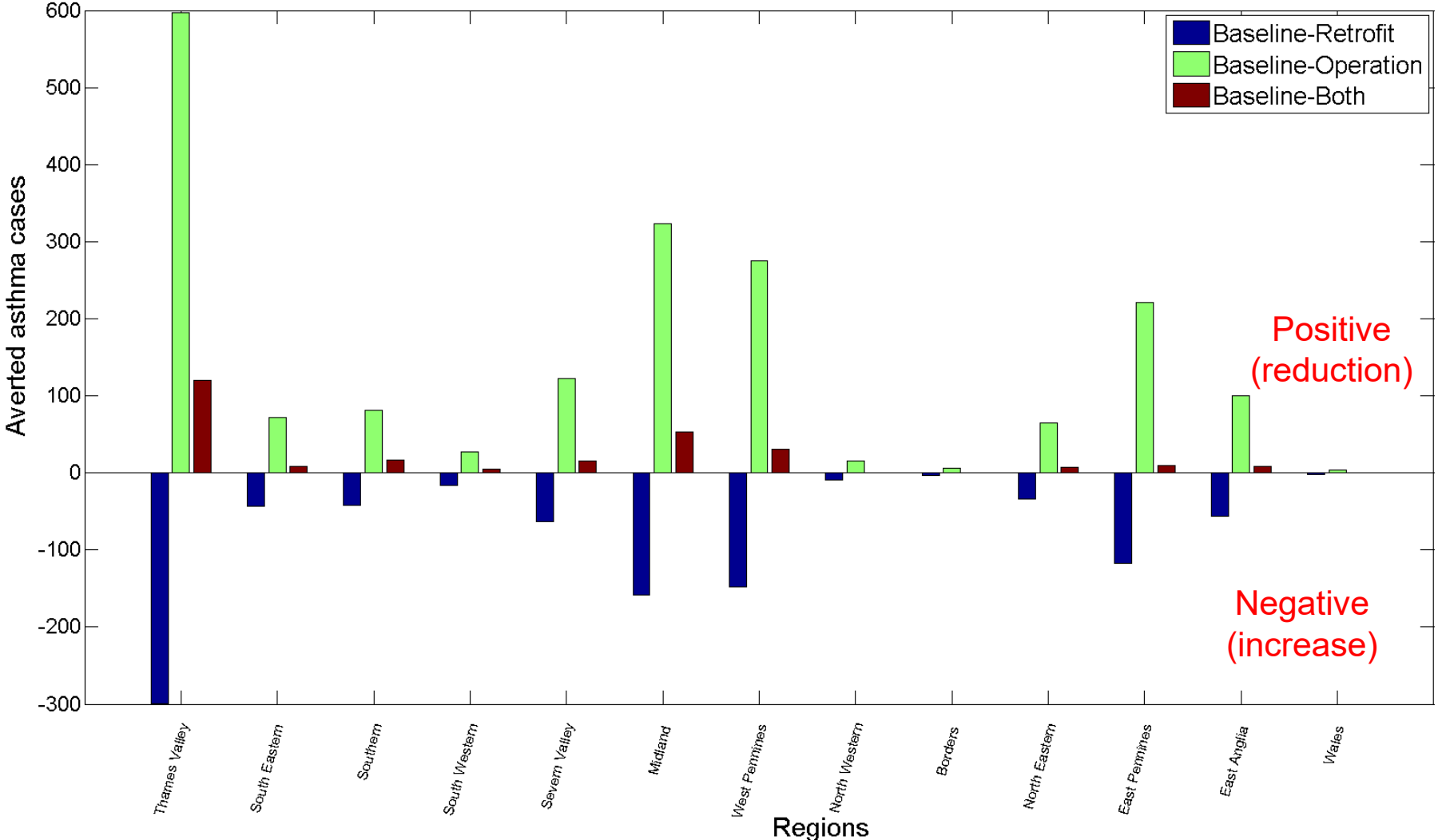
RESULTS

Averted asthma cases, England



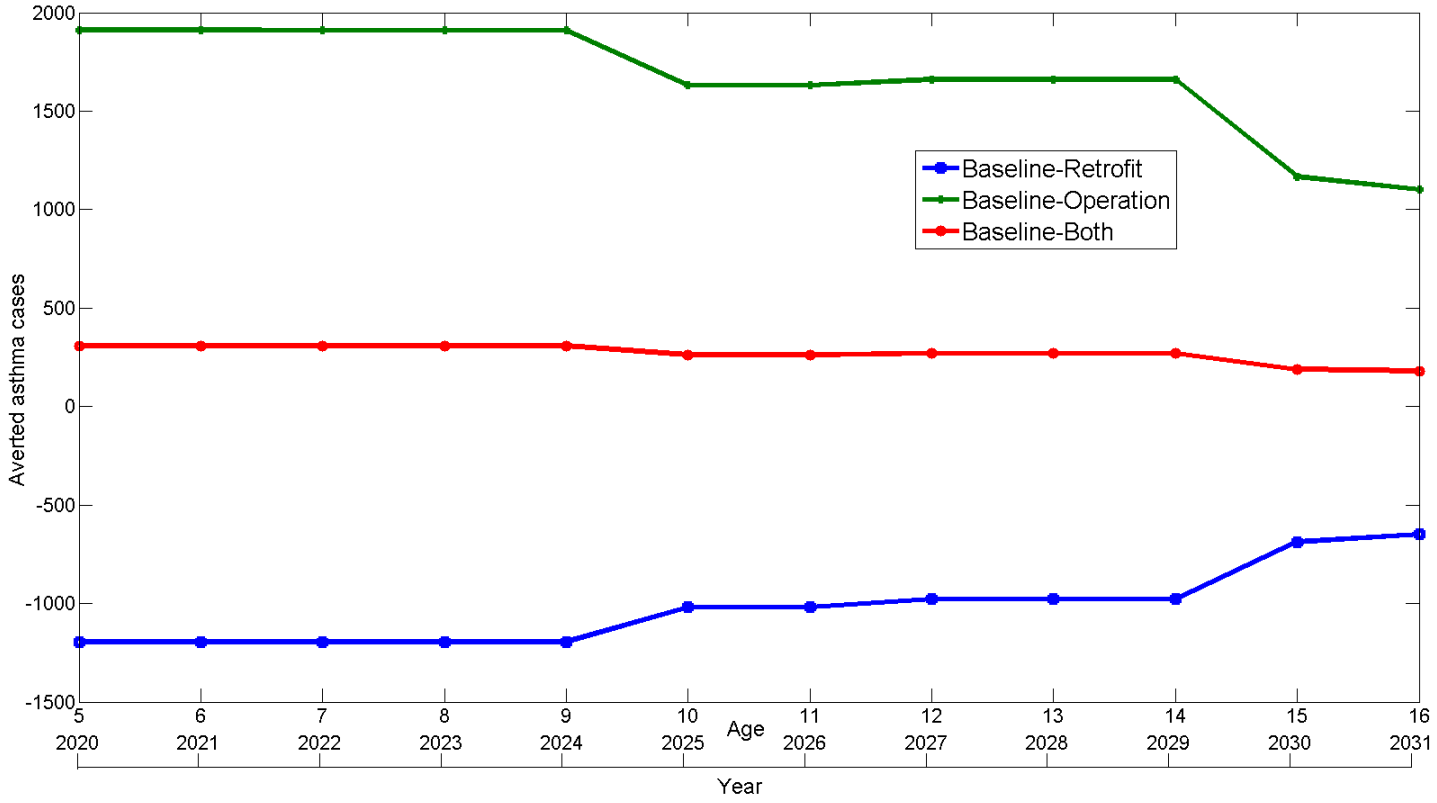
RESULTS

Averted asthma cases, 13 Regions



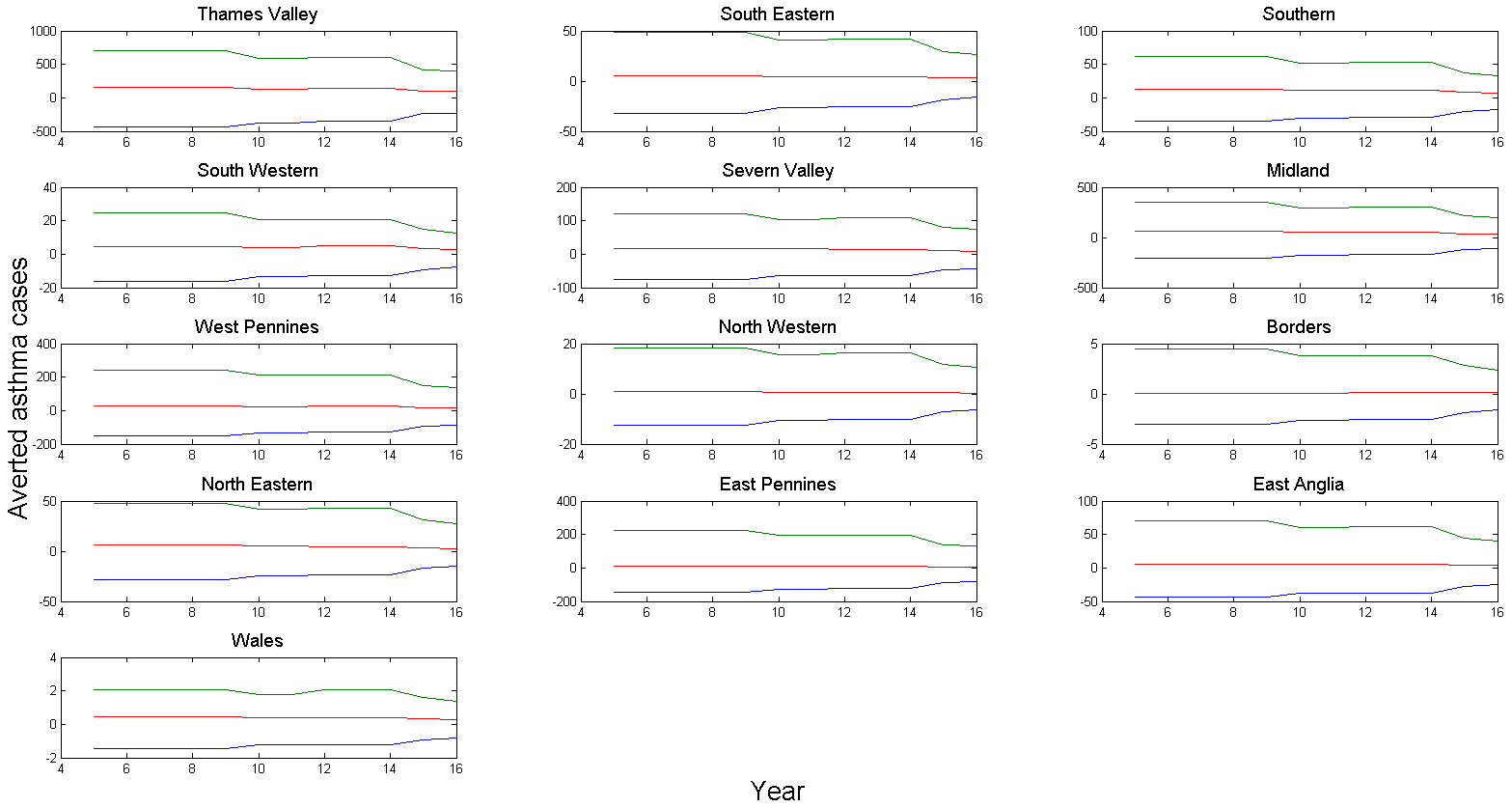
RESULTS

Cohort study- following up from 5 years of age to 16 years of age (11 years), England



RESULTS

- Cohort study- following up 5 years of age for 11 years, 13 Regions



Conclusion

- Improved energy efficiency also increases internal temperatures, leading to increased window opening and increased entry of ambient pollution. The net effect on NO2 and asthma depends critically on the building operation strategy.

- The findings from this study make several contributions to fill the knowledge gap about the impact of retrofitting schools on internally-generated pollutants and their effects on health.

- Further energy efficiency strategies coupled with operational measures should be applied to both reduce health effects and meet zero carbon emissions required.

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  - Jie Dong *(UCL)*
  - Zaid Chalabi *(UCL)*
  - Dejan Mumovic *(UCL)*
  - Anna Mavrogianni *(UCL)*
  - *Filiz Karakas (LSHTM)*
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THANK YOU

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Retrofit Strategies and Operational Measures

❖Retrofit Strategy (*) includes

- External 150mm of EPS insulation added:0.19, Permeability (m3/h.m2 @50Pa):0.89, Glazing U-value (W/m2.K):Triple with argon + low emissivity glass 0.75

❖Operational Measures (**) includes

- Wall albedo updated from 0.7 to 0.1 solar and visible absorbances.
- Curtain rules (window blinds with shading control added with setpoint of 120W).
- External shading (Adding shading: Overhang 0.05m above window 90deg, 0.8m depth)
  Increased thermal mass (50mm thickness of cast concrete added to internal walls as thermal mass).
- Night ventilation (Passive ventilation).
- Increased ventilation (flow increased through ventilation by increasing the height factor of the opening from 0.1 to 0.3 and start height factor from 0.9 to 0.7