

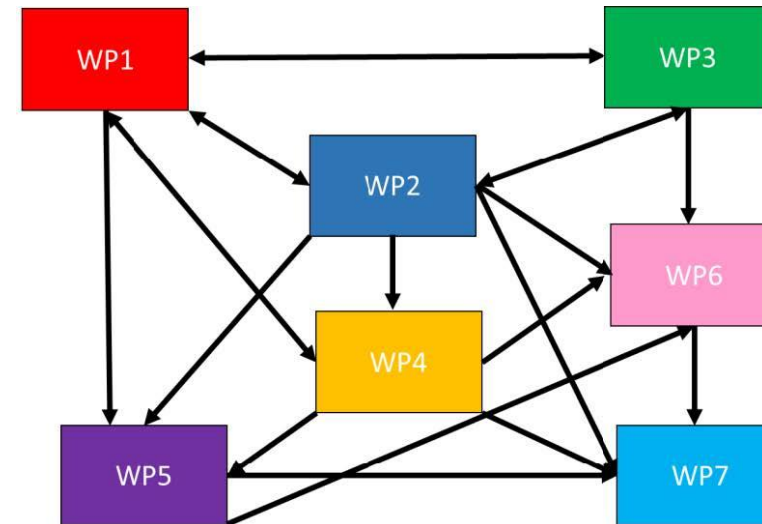
The impact of air change rates on the indoor air chemistry of homes in Bradford: a modelling study within the **INGENIOUS** project

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Understanding the sources, transformations and fates of indoor air pollutants

- 315 homes recruited, surveyed and measured
- Over 3.5 million indoor air quality observations from low-cost sensors
- See Nic's poster!

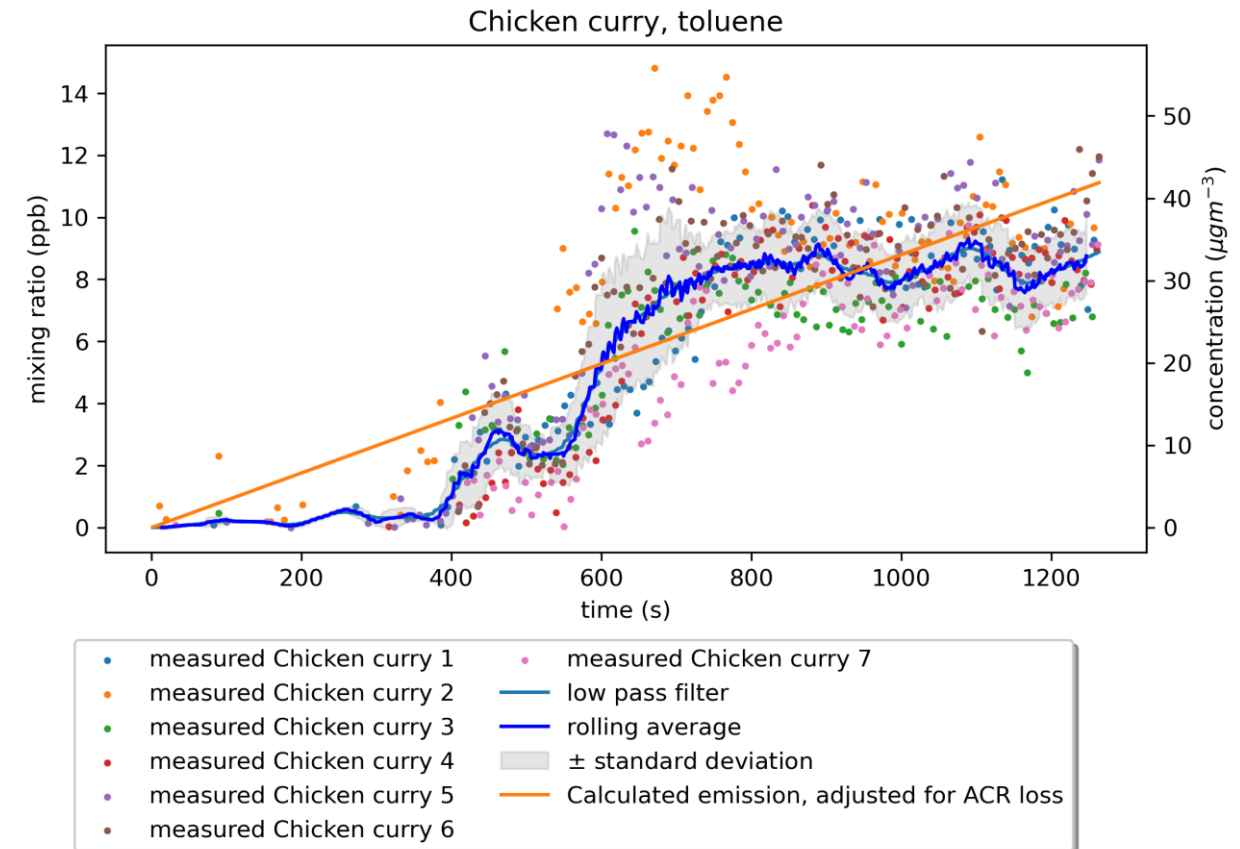


WP1: Controlled laboratory experiments
WP2: Survey of indoor AQ, occupant behaviour and health in real UK buildings
WP3: Mobile emissions measurements
WP4: Insight into chemical transformations indoors
WP5: Identifying the potential health impacts of indoor air pollution mixtures
WP6: Co-production and evaluation of behaviour change interventions
WP7: Communication and translation to policy for future solutions

Figure 1: Interconnections between workpackages

Cooking emissions

- Standardised 6 recipes, chicken curry used in this work
- Continuous VOC measurement using SIFT-MS
- 1 whole air canister collection per recipe for GC-MS analysis
- Emission rates calculated for 39 species



Air change rate calculations

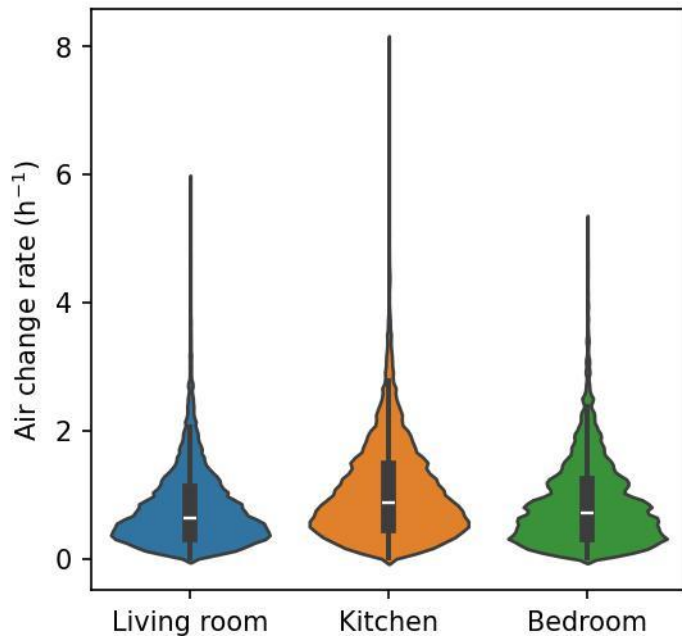


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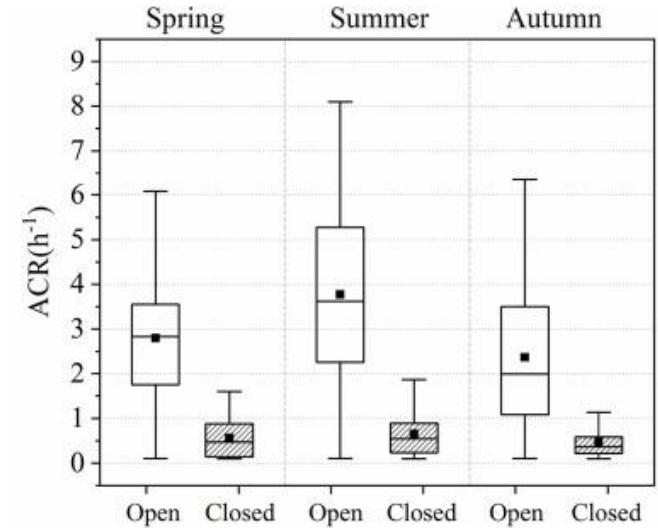


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- Calculated from CO₂ decay rate
- Median rates per season used as background
- Intervention (opening a window) assumed to cause a factor of 5 increase in air change rate based on Liu et al. (2022)



Season	Median air change rate (h ⁻¹)	Intervention air change rate (h ⁻¹)
Spring	0.84	4.2
Summer	0.79	3.95
Autumn	0.83	4.15
Winter	1.02	5.1



Liu, S. *et al.* (2022) 'Associating occupants' interaction with windows with air change rate --One case study', *Building and Environment*, 222, p. 109387. Available at: <https://doi.org/10.1016/j.buildenv.2022.109387>.

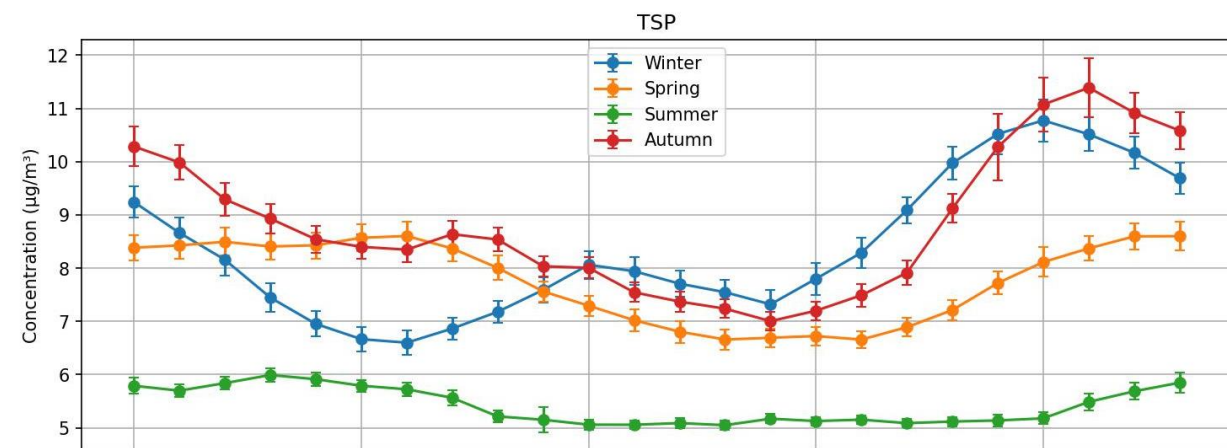
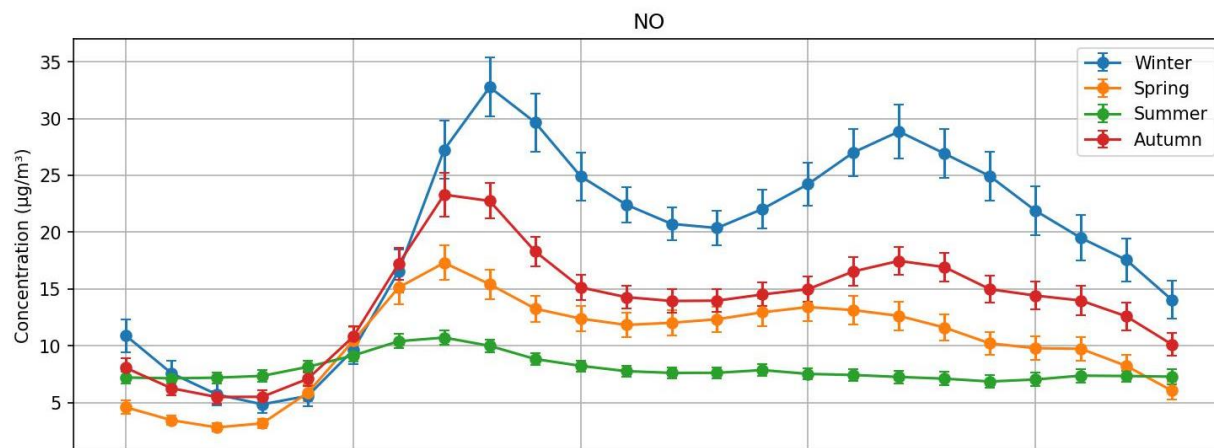
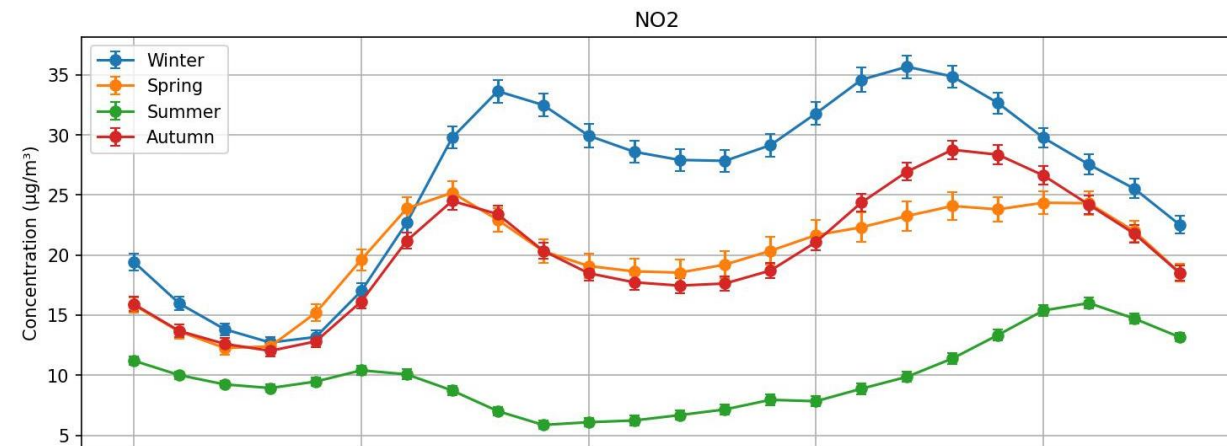
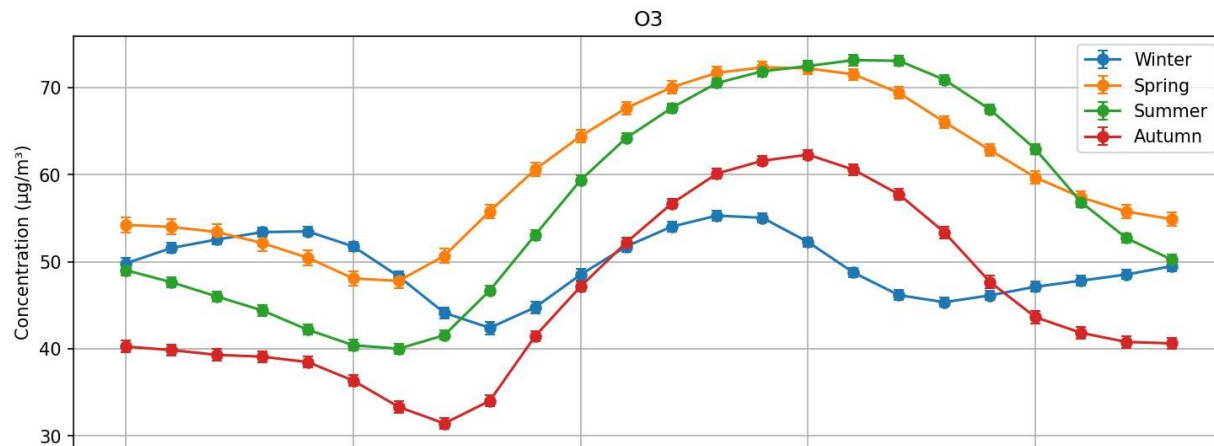


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Outdoor pollutants

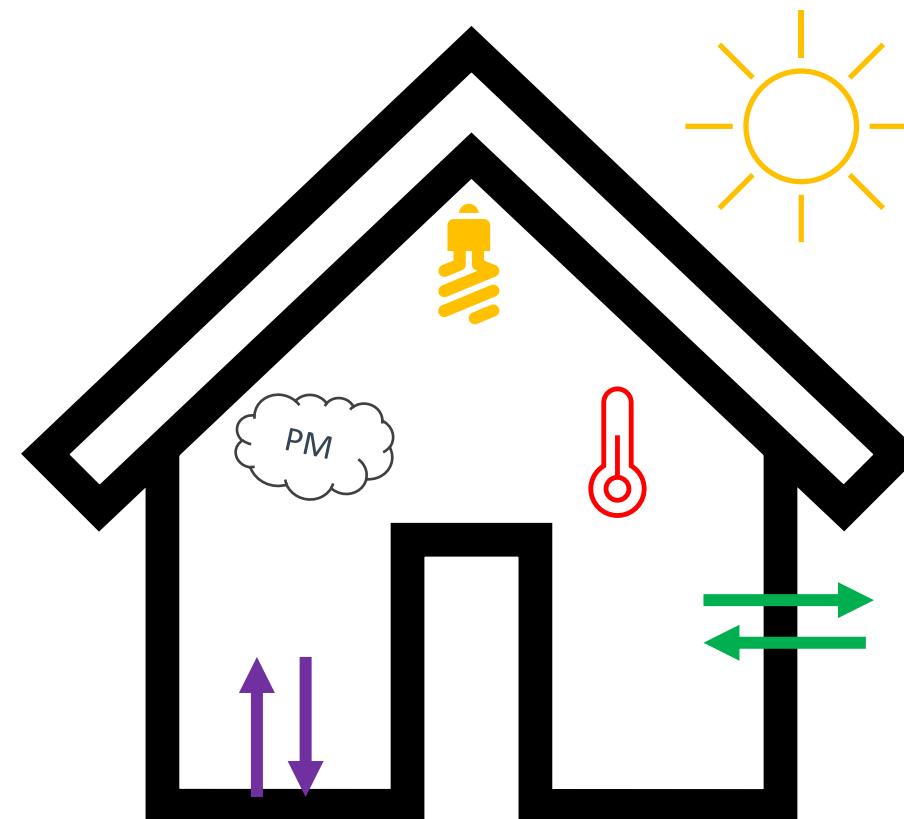
Diurnal profiles combined from sensors located across Bradford (n=25) and additional sensors in Leeds (n=2) and Dewsbury (n=1) during the campaign period. Split by season.

These include AURN, Zephyr, AQMesh and city council reference measurements.



Indoor Chemical Model in Python

- Open-source community box-model¹
- Utilises the Master Chemical Mechanism²
- Designed to capture the realistic evolution of indoor air chemistry
- Easy to use
- Has a detailed user manual



1. Shaw, D., & Carslaw, N. (2021). An open source Python box model for indoor air chemistry. *Journal of Open Source Software*, <https://doi.org/10.21105/joss.03224>

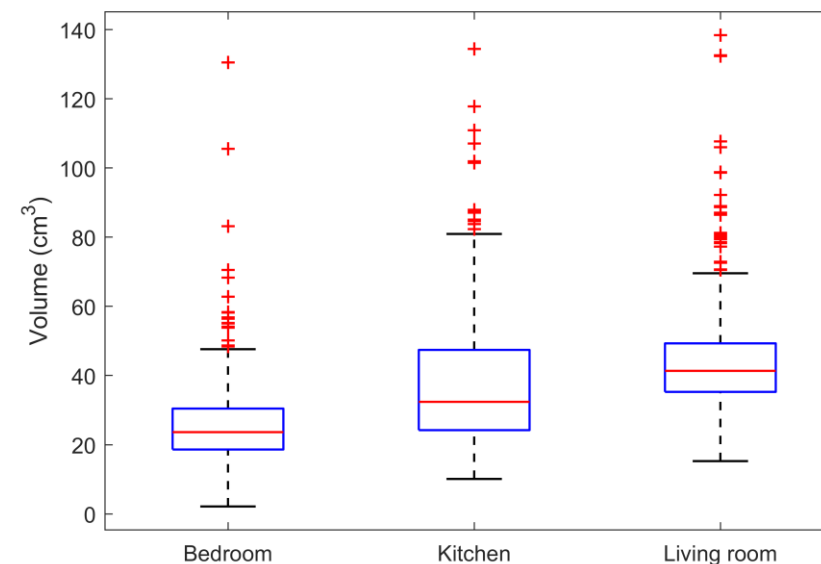
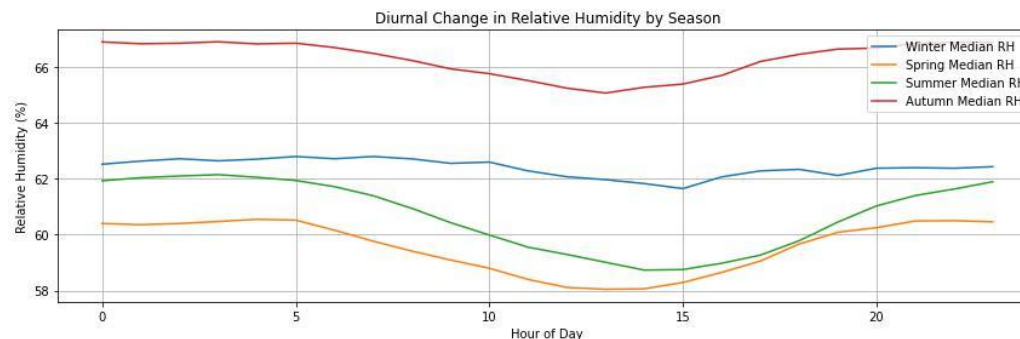
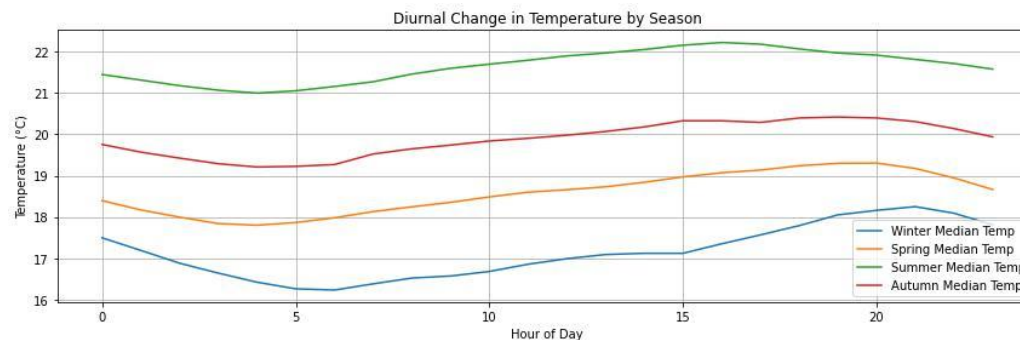
2. Jenkin, M. E., Saunders, S. M., & Pilling, M. J. (1997). The tropospheric degradation of volatile organic compounds: A protocol for mechanism development. *Atmospheric Environment*, *31*(1), 81–104. [https://doi.org/10.1016/S1352-2310\(96\)00105-7](https://doi.org/10.1016/S1352-2310(96)00105-7)

Other input parameters

<p>Temperatures (°C). Median values</p>	<p>Winter: 17.1 Spring: 18.5 Summer: 21.8 Autumn: 19.9</p>
<p>Relative humidity (%) Median values</p>	<p>Winter: 62.3 Spring: 59.4 Summer: 59.9 Autumn: 66.3</p>
<p>Volume (m³) Median value</p>	<p>32.4 (Kitchen)</p>
<p>Surface areas (m²) Median value of total surface area scaled to ratios for a kitchen from Carter (2023)</p>	<p>Soft furnishings: 2 Painted: 24.61 Wood: 16.51 Metal: 7.72 Concrete: 1.13 Paper: 0.19 Plastic: 7.15 Glass: 1.5 Human: 2 (one adult)</p>



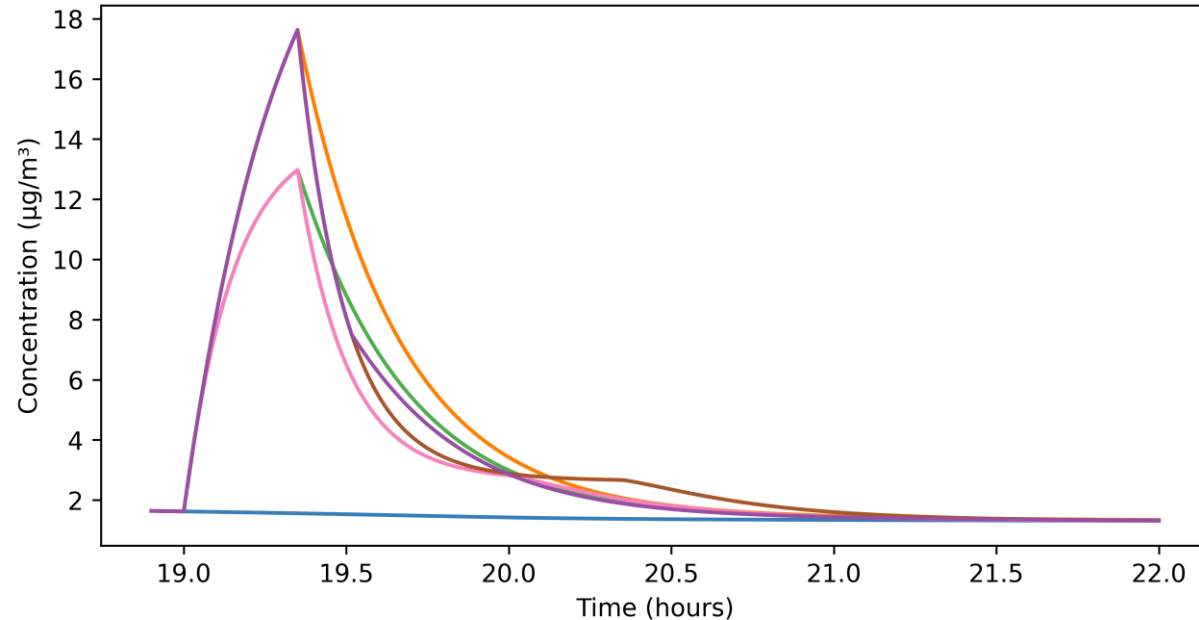
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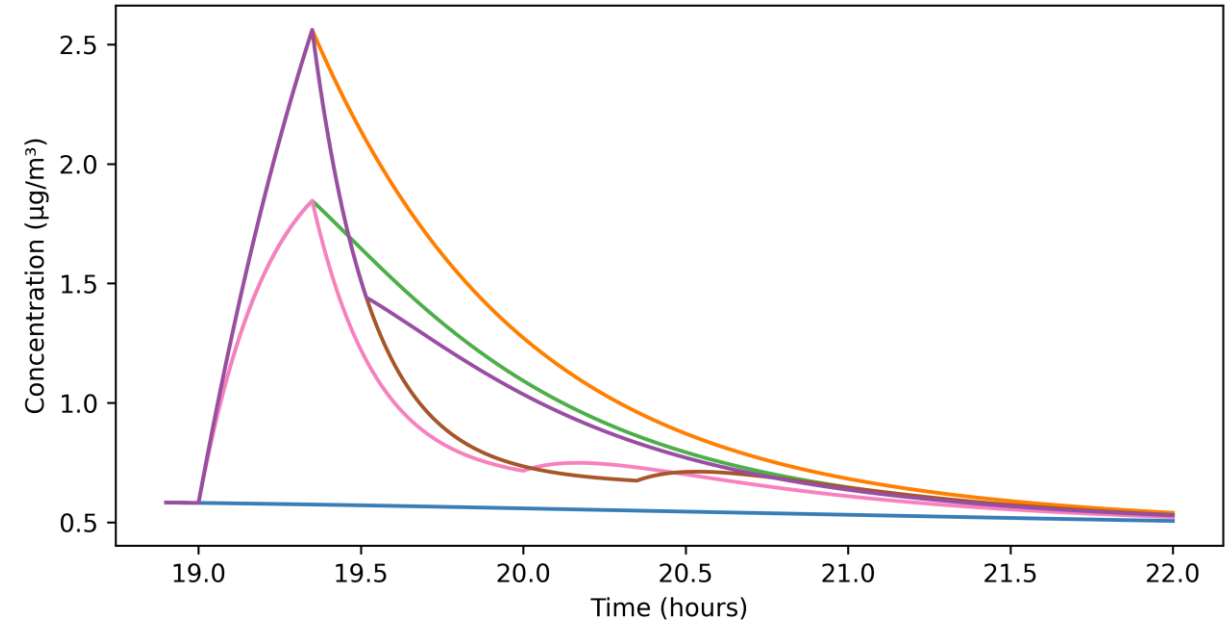
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Results

Formaldehyde, 5x ACR intervention



Octanal, 5x ACR intervention

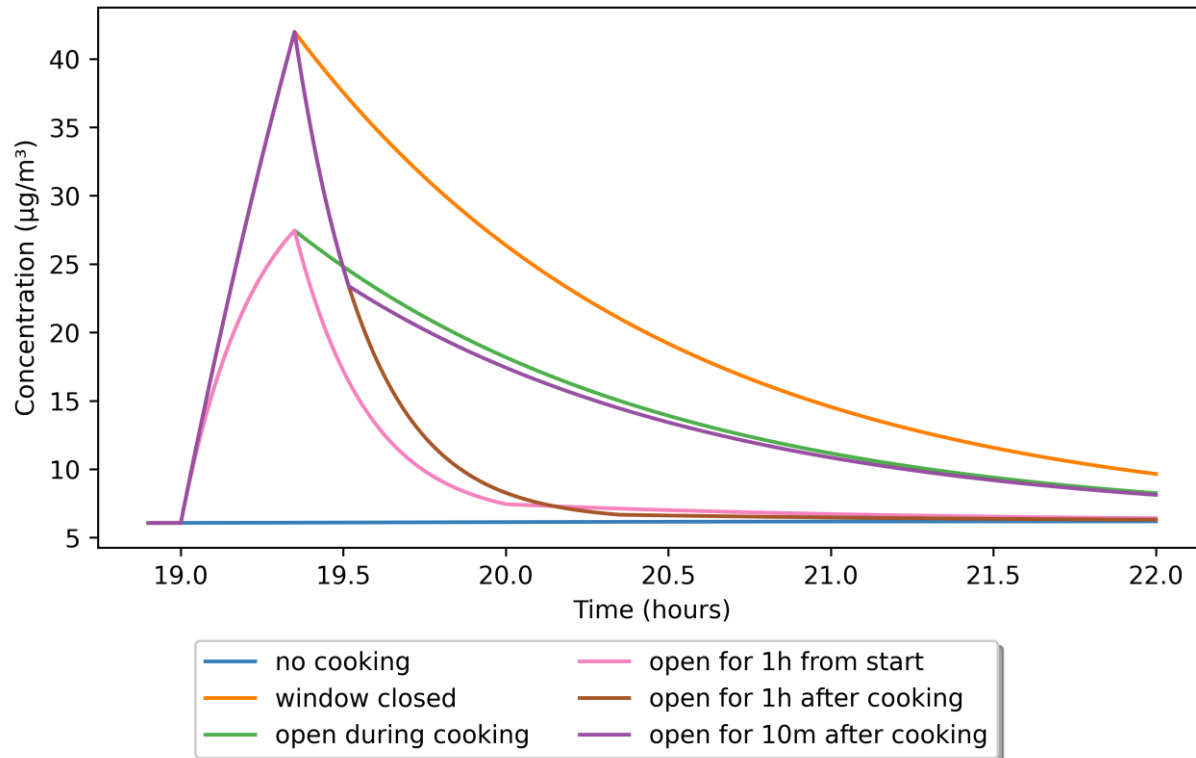


- Cooking at 19:00
- Chicken curry, 21 minute emission
- Summer outdoor concentrations and air change rates



Results

Toluene, 5x ACR intervention



Percentage reduction in exposure

	Formaldehyde	Octanol	Toluene
Open during cooking	14.9	13.6	27
Open for 1h from start	21.9	26.2	52.6
Open for 1h after cooking	8.5	19	45.2
Open for 10m after cooking	10.3	12	24.3

- Cooking at 19:00
- Chicken curry, 21 minute emission
- Summer outdoor concentrations and air change rates



Why do (and don't) people ventilate their homes?

Study 1 interviews:

- Semi-structured interviews with 30 participants (mean age = 44 years; 60% White, 37% Asian; 100% female) from the Born in Bradford Growing Up study cohort
- Interview transcripts analysed via hybrid inductive/deductive content and thematic analysis to identify the barriers to and facilitators of ventilation behaviours

Study 2 survey:

- Online survey of 310 participants (mean age = 46.63 years, SD = 15.9 years; 82.9% White, 8% Asian, 4% Black; 51.6% female) recruited from Prolific to identify the barriers to and facilitators of ventilation behaviours

Questions were based on the COM-B (Capability, Opportunity, Motivation – Behaviour) Model (Michie et al., 2011), a framework for understanding behaviours in terms of people's physical/psychological capability, physical/social opportunity, and automatic/reflective motivation



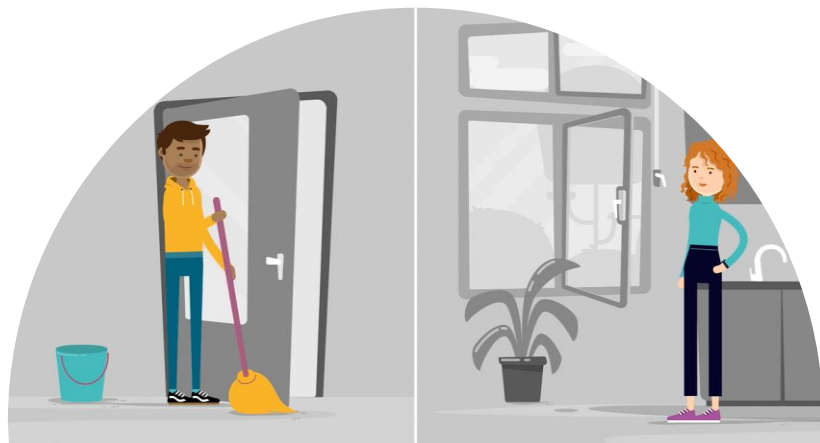
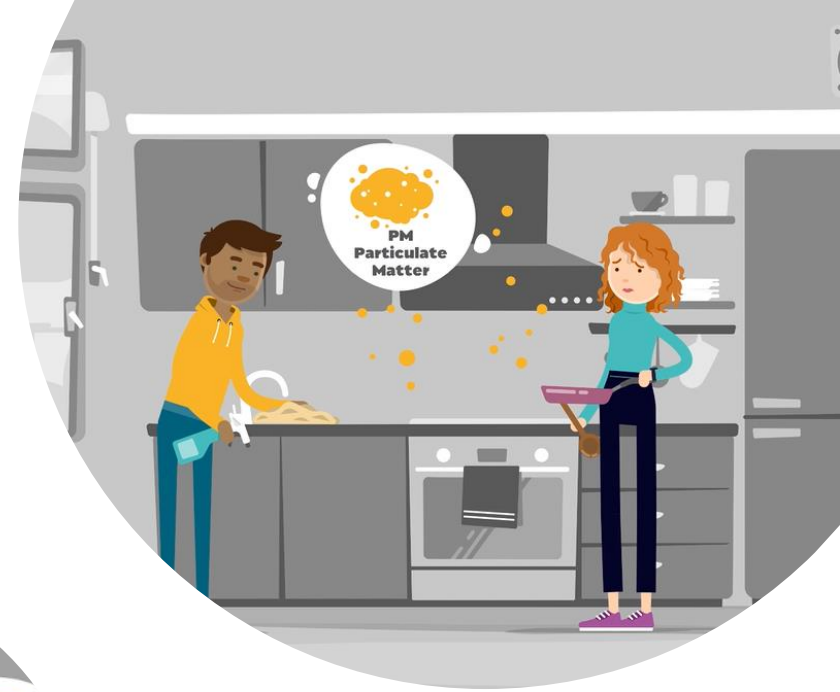
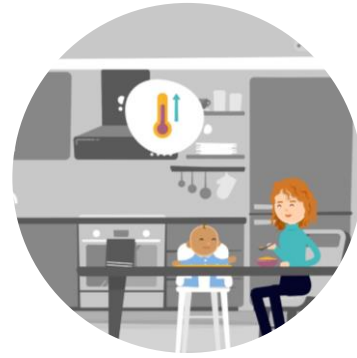
Key Results

- Participants had good knowledge of key sources of indoor air pollution and that ventilation could reduce indoor air pollution...but most hadn't really thought about indoor air pollution
- Participants had less knowledge about the health impacts of indoor air pollution, and ventilation tended to be motivated more by concerns about comfort than health
- Many participants believed that they have good air quality in their homes; and on average, participants thought that air pollution outdoors was higher and more harmful to health
- Other key barriers to ventilation:
 - Poor weather
 - The financial cost of heating while ventilating, or of using an extractor fan/cooker hood
 - Noisy/faulty extractor fans/cooker hoods
 - Security concerns
 - Difficulty remembering to ventilate



Overcoming barriers to ventilation behaviours

- Behaviour change intervention (4 min animated video) co-designed (with Bradford community members) to encourage people to ventilate their kitchens
- Does it increase ventilation behaviour, reduce indoor air pollution (PM, TVOCs) and improve health?
 - Currently evaluating acceptability and initial effectiveness in 90 households from Born in Bradford



Any questions?

More details at ingenious.york.ac.uk



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INCHEM-Py can be downloaded from
<https://github.com/DrDaveShaw/INCHEM-Py>