Contribution ID: **90** Type: **Poster**

Modelling indoor NO2 exposures to enable health impact assessment of gas cooking emissions

Background/Objective
Gas cooking emits NO2, a gas contributing to poor indoor air pollution, and leading to indoor concentrations often exceeding outdoor levels and air quality guidelines. Electric hobs, on the contrary, do not involve combustion and thus do not contribute to increasing indoor NO2 levels. Gas cooking was prevalent in 33% of European households in 2022, although usage varies considerably by country (0-74%), and it is declining (1). Health risks associated with gas cooking include increased risk of pneumonia and COPD in both children and adults, and potential links to asthma and other respiratory symptoms (2). Likewise, NO2 exposure is also associated with increased mortality, lung cancer risk, hospital admissions for respiratory issues, and exacerbated asthma in children (3). Given the widespread use of gas cooking and the associated health risks related to NO2 exposure indoors, it is crucial to assess its overall health impact. In order to perform such health impact assessment, knowledge of the concentrations of NO2 concentrations inside households that use gas cooking is required. Likewise, information on the distribution of NO2 concentrations in households that cook with appliances that do not emit NO2, like electric hobs, is also required. This study aims at estimating the NO2 concentrations indoors in European households that cook with gas and electric appliances that will allow to conduct a health impact assessment associated with NO2 exposure during cooking with gas hobs.

Methods
Concentrations of NO2 indoors in households that use gas and electric cooking appliances were estimated by combining indoor-to-outdoor (I/O) NO2 ratios with ambient NO2 modelled concentrations available at the European Environment Agency (EEA) (4). Concentrations were estimated at small regional unit area (i.e. at NUTS- 3 level). In order to calculate the I/O NO2 ratios in households that use gas and electric cooking appliances, information on indoor NO2 concentrations reported in a recent and comprehensive study conducted in 7 European countries (5) were divided by the ambient NO2 EEA modelled concentrations at each geolocation. The individual I/O NO2 according to cooking appliance were aggregated for each of the four clusters (Eastern Europe, Southern Europe, North-Western Europe and United Kingdom, UK) that the countries are classified onto according to the literature (6).
Indoor NO2 levels for hypothetical households using gas or electric cooking were estimated combining mean ambient NO2 concentrations at each NUTS- 3 level, derived from the EEA's 2021 maps for each European location, with the relevant indoor-to-outdoor NO2 concentration ratios derived to each country cluster.

Results
Spatial distribution of NO2 concentrations according to cooking fuel type in every small regional unit area (i.e. at NUTS- 3 level) for all countries in the EU and the UK were calculated. A clear difference emerges between estimated average concentrations within homes according to cooking methods. Homes using gas appliances have higher estimated indoor NO2 levels than the concentrations modelled outdoors by the EEA. On the contrary, homes using electric appliances have lower estimated indoor NO2 levels than outdoors. Furthermore, indoor NO2 concentrations in homes using gas cooking exceed the World Health Organization's (WHO) recommended annual limit of 10 μg/m3 guideline in 14 countries. No such exceedances of the WHO guideline were estimated in homes using electric cooking.

Conclusion
This study has estimated indoor NO2 concentrations according to cooking fuel type in every small regional unit area for all countries in the EU and the UK. The current modelled indoor NO2 concentrations can be used to estimate the health impacts and economic costs across the EU and UK associated with mortality and asthma related with exposures to NO2 emitted from gas cookers in Europe.

Keywords
NO2, gas cooking, indoor air quality

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