

Social and spatial inequalities in Nitrogen Dioxide (NO₂) air pollution across Ireland^{1, 2}

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INTRODUCTION

Nitrogen dioxide NO₂, a major air pollutant stemming primarily from transport-related fossil fuel combustion, presents a critical public health challenge. Exposure to NO₂ irritates the airways, exacerbating respiratory conditions such as asthma and Chronic Obstructive Pulmonary Disease (COPD). Moreover, long-term exposure is associated with other diseases including stroke and diabetes mellitus, increases the risk of premature mortality, and generates considerable costs to the healthcare system. Although the adverse health effects of air pollution are well-recognised within the Irish policy framework, notably in initiatives like *Healthy Ireland*, *Sláintecare*, and the *Clean Air Strategy*, research into unequal population exposure remains scarce.

A key policy concern is the potential for socioeconomically disadvantaged or vulnerable populations (e.g., lower-income households) to be exposed to higher NO₂ concentrations. This study aims to fill this knowledge gap by exploring the link between ambient (outdoor) NO₂ concentrations—a localised pollutant peaking near emission sources—and the demographic, social, and economic characteristics of small areas across Ireland. This focus on a highly localised pollutant necessitates a significantly finer analytical resolution.

DATA AND METHODS

This investigation uses the most contemporary NO₂ concentration data for Ireland (2010–2020), derived from land use regression models to achieve a high resolution of 0.0025 km². This spatial data was linked to the 2022 Irish Census small areas and two key socioeconomic sources: the Pobal Deprivation Index and the Small Area Population Statistics (SAPS). Using both descriptive and statistical models, the analysis examined whether areas with greater deprivation experienced higher NO₂

¹ This Bulletin summaries the findings from: Hoy, A., Mohan, G., and Nolan, A. (2025) Investigating inequalities in NO₂ air pollution concentrations on novel indicators relating to small spatial areas. *International Journal for Equity in Health*. Available at: <https://doi.org/10.1186/s12939-025-02674-1>

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concentrations. The study was stratified by urban and rural areas and also included analyses of educational attainment, ethnicity, housing tenancy, self-rated health, and smoking rates etc., aiming to provide data on environmental inequality to inform policy.

RESULTS

The analysis reveals that Ireland experienced relatively low average annual NO₂ concentrations over the 2010–2020 decade, below the World Health Organizations' Air Quality Guideline level (10 µg/m³), though urban areas maintained approximately twice the level of rural areas, reflecting higher vehicular traffic.

Crucially, the study uncovered significant disparities in average NO₂ concentrations across population subgroups, with the national analysis displaying a U-shaped pattern across the overall deprivation measure and educational attainment; specifically, the most and least disadvantaged quintiles experienced the highest NO₂ concentrations. This U-shaped trend was more pronounced in urban areas, where housing affordability likely compels disadvantaged groups to reside near major polluting roads, while more advantaged groups may live in more affluent urban geographies. Furthermore, small areas (SAs) with higher shares of non-white ethnic populations were exposed to higher NO₂ levels across national, urban, and rural analyses, and SAs with greater shares of non-owner-occupied housing (renters) also recorded higher NO₂ concentrations. In contrast, a positive finding was that SAs characterised by greater proportions of children and older people tended to live in areas of lower NO₂ pollution, which is beneficial given their increased vulnerability to air pollution effects.

CONCLUSIONS

The research provides the first evidence of NO₂ environmental inequalities in Ireland, specifically showing that NO₂ concentrations are highest in areas with greater shares of non-white populations and renters (non-owner-occupied housing). These issues are most acute in urban areas. Although a U-shaped pattern was found regarding deprivation, indicating high NO₂ concentrations for both the most and least advantaged, it is a significant concern because the disadvantaged are at greater risk of adverse health outcomes due to pre-existing vulnerabilities (e.g., poorer quality housing, chronic health conditions). These findings are vital for policymakers, offering evidence to target mitigation policies toward vulnerable populations, supporting Ireland's commitment to new EU and WHO air quality guidelines.