

Geospatial air quality complaints and implications for urban respiratory health



Poor indoor air quality (IAQ) is associated with various adverse health outcomes, most notably respiratory conditions such as asthma, COPD, and lung cancer. Outdoor air quality (OAQ) is consistently worse in urban areas, such as New York City (NYC), and this environment can exacerbate poor IAQ in cities due to smaller dwelling size, inadequate ventilation, and high population density. Consequently, IAQ can be substantially worse than outdoor air quality, where air quality concerns might be compounded by neighbourhood socioeconomic status.

The New York City Department of Health and Mental Hygiene (DOHMH) maintains public records of complaints filed regarding indoor environmental concerns. Herein, we present an analysis of 76 298 IAQ records from July 10, 2010, to Dec 31, 2022, exploring their health implications.

Data were obtained from the DOHMH Indoor Environmental Complaints records. The dataset includes individual-level information, such as the geographical location and nature of the complaint. We analysed the distribution of complaint type across NYC boroughs, weighting the number of complaints by population size to account for differences in density. IAQ complaints greatly surpass other environmental event reports, and both complaint volume and type across boroughs are statistically significant with Chi squared (χ^2 ; figure 1).

Evaluating reporting trends by complaint type showed an increased rate of IAQ complaints, whereas other reporting categories have remained consistent. (figure 2). Elevated IAQ complaints have contributed to the overall increase in total reporting in the past few years; however, we found this relationship to be proportional to the increase in population. A visual representation of the geospatial distribution of IAQ complaints shows each zip code shaded according to the number of complaints, identifying areas that might require more resources or interventions to improve IAQ (figure 3). A more granular analysis shows that residents in the Upper West Side, West Harlem, and the Lower East Side file a larger share of the Manhattan complaints, with one zip code in Queens (a borough with fewer complaints) filing more complaints than any other NYC zip code, variations attributable to a myriad of factors, including local outdoor air quality, adjacent neighbourhood commercial tenancy, intrinsic building qualities, and resident temperament.

OAQ has been long associated with respiratory health concerns—eg, with childhood asthma. Outdoor pollutants commonly linked to respiratory issues include fine particulate matter ($PM_{2.5}$), ozone, nitrogen dioxide, and sulphur dioxide. OAQ, with influences imparted by seasonal weather conditions such as heat and humidity, as well as

environmental events, is challenging to regulate. Notably, the Canadian wildfires made NYC the most polluted city in the world on June 7, 2023. With an increasing frequency of wildfires and other natural disasters, poor air quality will continue to be a pressing issue.

Unlike the dynamic environmental factors that dictate outdoor air quality, efforts to improve IAQ can yield more controllable results. Indoor air pollutants including $PM_{2.5}$, carbon monoxide, volatile organic compounds (such as household cleaning agents containing benzene, toluene, xylenes, and intrinsic building materials using formaldehyde), along with occupant habits such as cooking or smoking substances (such as tobacco or e-cigarettes), each contribute to poor IAQ. The negative effect of these pollutants is exacerbated by inadequate ventilation, a common feature of many energy-saving buildings and homes.

Similar to OAQ, indoor air pollution has a long-standing relationship with asthma in childhood. Notably, neighbourhoods with high asthma prevalence in NYC have been linked with higher poverty and various social determinants of health. Although many complex biological and environmental factors contribute to asthma exacerbations in children, current data suggest that IAQ is a major contributor to this multifaceted issue.

The disease burden of poor IAQ is high, with household air pollution being associated with 1.8 million deaths and 60.9 million disability-adjusted life-years (DALY) globally in 2017. Although poor IAQ is a major health concern across all respiratory illnesses, the highest associations are with COPD and lung cancer. Poor IAQ continues to contribute to these chronic health conditions which pose large

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For more on **high asthma prevalence in NYC** see *Pediatr Res* 2019; **85**: 36–42

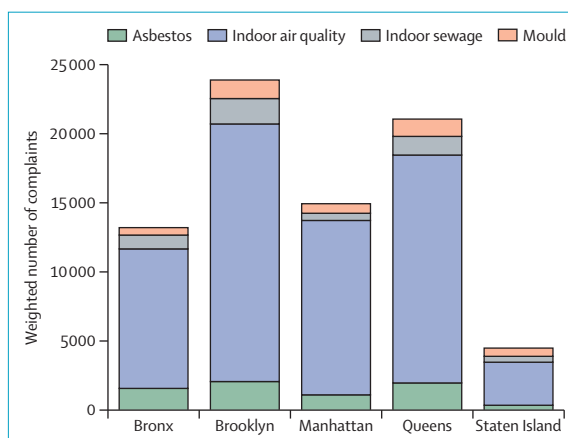


Figure 1: Weighted number of complaints for each borough by top four complaint types

Number of complaints per borough and type of complaints in each borough are significantly different ($p < 0.001$).

For more on **multiunit housing policies** see *Am J Public Health* 2012; **102**: 1868–71

For the **updated policy on prohibiting smoking** see *Tob Use Insights* 2019; **12**: 1179173X19859355

For more on **IAQ factors** see *Int J Environ Res Public Health* 2021; **18**: 3276

For **sustainable ventilation strategies** see *Renew Sustain Energy Rev* 2016; **59**: 1426–47

For more on **secondhand smoke** see <https://www.nyc.gov/assets/doh/downloads/pdf/survey/smoke-free-housing.pdf>

For the **e-nose platform** see *Appl Sci* 2019; **9**: 3435

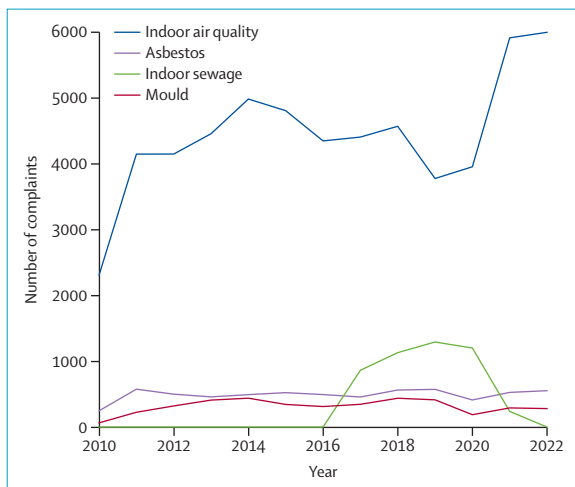


Figure 2: Number of the top four complaint types in New York City, 2010–22

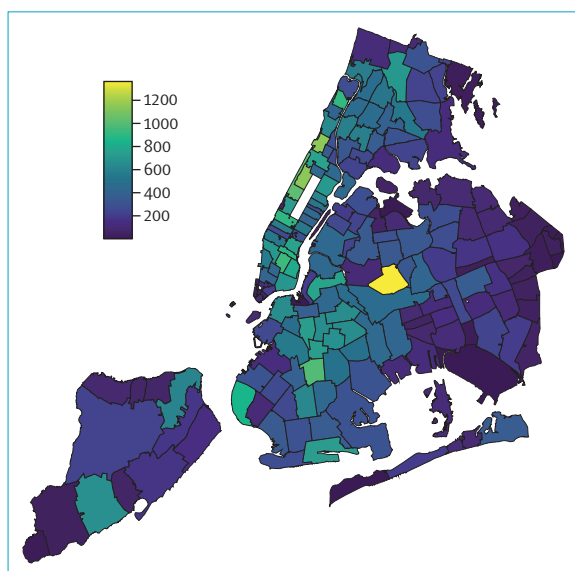


Figure 3: Spatial distribution of the number of indoor air quality complaints in New York City

Map colours represent the number of complaints per zip code, with lighter colours indicating a higher number of complaints.

health concerns and affect morbidity and mortality, along with having a role in prenatal and perinatal issues such as gestational diabetes and low birthweight, and a decline in cognitive performance in older people.

Given that a substantial portion of indoor pollutants are generated by building occupants, collaboration with building owners, managers, and tenants to prioritise IAQ is essential. Nearly 44% of multiunit housing residents in the USA report involuntary secondhand smoke incursion into their homes. The NYC Smoke Free Air Act prohibits smoking in common areas of buildings with more than ten units, but a policy that prohibits smoking in individual units applies to only 37% of multiunit housing owners as of 2015.

Although eliminating source problems is an essential step to improving IAQ, enhancing building ventilation is also important. Up to 60% of IAQ problems are related to insufficient ventilation within a building. Efforts to provide regular heating, ventilation, and air conditioning maintenance, while prioritising sustainable solutions for building ventilation, could yield potential health-related savings of up to US\$50 billion through reducing rates of respiratory illness, allergy and asthma exacerbation, and sick building syndrome (marked by adverse health effects temporally related to specific indoor environments).

The role of socioeconomic, racial, and ethnic factors in the unequal distribution of IAQ remains a challenging issue, in which the association of racial bias with PM_{2.5} exposure regardless of income might lead to higher incidence of cancer, respiratory health issues, and premature death. Although our data highlight the variations in IAQ across boroughs, this analysis does not attempt to factor in aspects of mean household income or racial composition in various zip codes based on census tract data. However, previous data show that 54% of New Yorkers living in the poorest neighbourhoods report regular exposure to secondhand smoke, compared with only 32% of those in wealthier NYC neighbourhoods.

Accurate monitoring of air quality will help to optimise efforts to improve IAQ. Although a variety of IAQ monitoring systems have been developed, most do not adequately assess real-time air quality and are too expensive to implement at scale. Recent developments, such as the emerging electronic nose or e-nose platform, are relatively low cost (around \$100) and can send mobile notifications when air quality approaches health-threatening levels. Complementing these technological advancements, policy makers will need to continue to prioritise efforts to improve IAQ by advancing building design and advocating for stricter smoke-free policies.

Our findings, showing prevalence and geospatial distribution of IAQ complaints across NYC, offer a unique perspective into the evolving trends and differential impact on residents of a large urban environment. These insights might serve as a platform for continued systemic changes in building design and spur multidisciplinary efforts to eliminate source exposure from cigarette smoke or other ambient air pollutants that exacerbate health outcomes, particularly among at-risk populations.

We declare no competing interests.

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